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HENRY S. GRAVES, Forester.

INSTRUCTIONS

FOR THE

BUILDING AND MAINTENANCE OF TELEPHONE LINES ON THE NATIONAL FORESTS.

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INTRODUCTION.

GENERAL.

Telephone lines on and near the National Forests assist in protection and administration and make the Forests more useful to the communities whose interests the Forests are to serve. The telephone system of the Forest Service must necessarily be of a simple character. The Service will build telephone lines only where they are necessary for protective or adminstrative purposes, and then only where there is insufficient business to warrant commercial companies in constructing lines. For the most part, the lines of the Forest Service will connect supervisors' and rangers' headquarters and lookout points with exchanges of commercial companies or with other logical switching centers.

COOPERATION.

Commercial companies and settlers should be encouraged to build lines on and near the Forests. The Service will cooperate with them by supplying, so far as possible, free poles and rights of way, with the understanding that there shall be in return an equitable arrangement as to free use of such lines for official business, and that the companies and settlers shall make reasonable effort to notify Forest officers of forest fires in the vicinity of telephone stations on such lines.

Cooperation involving ownership, divided or undivided, or joint construction, introduces a division of responsibility which may affect communication and maintenance, as well as future growth and extensions, and therefore will not be entered into without the special consent of the District Forester.

CONNECTIONS.

Trouble originating on any one part of a line is likely to put the whole line out of commission; therefore every precaution should be taken to safeguard against possible interference with the efficiency of the line when connecting with telephone stations or branch lines and with the terminal or switching arrangements.

CAPACITY LIMIT.

The number of telephones that can be allowed on Forest Service lines is of necessity limited. Each telephone added to the line increases the electrical load and lessens by this amount the reserve capacity of the line for future growth, and more particularly for emergencies. Because of the unusual exposure to which Forest Service lines are subjected, due to the character of the regions through which they pass, leakage and resistance may be so great in emergencies as to require all the reserve capacity; there are times when it is necessary to signal over the line from outlying and lookout stations, or from portable instruments cut in along the line or operating over emergency lines. Forest officers should have these points in mind when considering applications for special-use permits covering the connection of non-Forest Service telephone instruments. As a general rule such permits will not be issued on lines that will form a part of a circuit through a Forest.

CONSTRUCTION AND MAINTENANCE.

Inasmuch as Forest Service lines are primarily for fire protective purposes, they should embody the greatest possible reliability of construction, and every precaution should be taken to insure continuity and dependability of communication over them at all hours during fire seasons.

STANDARD CONSTRUCTION.

The standard construction shall be a pole line with brackets and glass insulators attached to the poles. A one-wire line (grounded circuit) of No. 9 BWG[1] Best-Best galvanized iron wire will be the usual construction. Where necessary, a two-wire line (metallic circuit) of copper wire may be used. No copper wire, however, may be used without first obtaining the approval of the district office. It is not possible to talk any farther over a metallic circuit line than over a grounded circuit line. Where the line is in excess of 125 miles long it will probably be necessary to resort to copper wire. It can not be used with swinging insulators and should not be used except on a strictly pole line. Metallic circuit lines are used only where there is outside interference, such as static electricity, induction from other lines, or trouble from power-transmission lines.

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[1] Birmingham wire gauge.

ILLUSTRATIONS.

These instructions are issued to secure standardization and uniformity in practice and methods. In cases where considerable variation in these instructions is proposed, either in material or methods, the matter must first be submitted to the district office. Any details indicated in one part of the text and not in another, or in the supplementary illustrations and not in the text, should be executed as if indicated in both. Dimensions upon the illustrations should be followed as closely as conditions will permit.

LOCATING AND ROUTING.

In deciding the location of the lines:

(1) Take into account the most logical switching centers, where they exist, for connection with other lines.

(2) Consider the possibility of short branch lines for connection with lookout points and ranger and guard stations, where such points are not in the direct course of the line.

(3) Follow roads and main trails, so as to facilitate frequent inspection and simplify future maintenance.

(4) Avoid steep slopes, cliffs, river beds, arroyos, and streams, and canyons more than 500 feet across; this will lessen the exposure to snow and landslides, to floods and high winds.

(5) Avoid electric light, power, and high-tension transmission lines as far as possible; do not parallel a high-tension transmission line carrying over 5,000 volts nearer than one-half mile; do not approach such a line for the purpose of crossing it, except at right angles. The telephone line should stop at a pole on either side not closer than 150 feet from the transmission line, and cross underground. For method of crossing see sections on "Foreign lines" and "Crossings."

(6) Take into account the probabilities of future growth and extensions.

(7) Make the line as short and direct as practicable consistent with the preceding instructions.

RIGHT OF WAY.

If it is proposed to build any part of the line off the Forest, or over alienated land within the Forest boundary, right of way must first be obtained, drawn up on the regular form, which will be furnished by the district forester on request. Verbal permission is not sufficient.

SURVEY.

Ordinarily a preliminary survey is necessary in order that the length of the line and its cost may be estimated. The location determined by the survey, however, need not be taken as final; deviations from it should be made if it is found, during the course of construction, that greater reliability can thus be secured. The line should be carefully laid out by the foreman in charge of the work and stakes set to show the proper location of the poles.

MARKING STAKES.

Marking stakes should be set in line and at the intervals the poles are to be spaced, to show the pole positions. Each stake may be marked with the height of the pole for that particular position, the depth of the hole, whether an anchor hole or stub hole should be dug, if the pole is to be guyed or braced, and the amount of rake[1] at curves and corners.

CLEARING RIGHT OF WAY.

A right of way at least wide enough for a bridle trail should be cleared when the line runs through dense underbrush or chaparral; small trees directly under the line wire which by their future growth would touch the wire should be cut down at the outset. All trees and limbs, alive or dead, hanging over the cleared right of way, which would be likely to fall on, catch, or rub against the wire, or which may be borne down upon the line by wind or weight of snow or sleet in winter, should be cut. In other words, anything that would at the present, or in the very near future, cause trouble on the line should be cleared before or at the time the wire is being strung. There should be at least 4 feet clearance from foliage on all sides of the line wire throughout its entire length.

On account of the expense of clearing, dense growth should be avoided, though not at the sacrifice of the proper location of the line.

All slash will be properly disposed of so as to lessen the fire hazard.

CUTTING, SEASONING, AND TREATING POLES.

CUTTING POLES.

All poles should be cut from live or sound dead standing trees and should be free from heart or butt rot or other defects which would weaken the pole. When possible, poles and braces should be cut in winter to secure better seasoning. They should be peeled as soon as

[1] See section on "Setting poles" for definition of "rake."

cut and all knots and branches trimmed close. They should be reasonably straight and of the following dimensions:

Length.	Top diameter (minimum).	Length.	Top diameter. (minimum).
Feet.	*Inches.*	*Feet.*	*Inches.*
18	5	35	6
22	5	40	6½
25	5½	45	7
30	6		

When the line will be subject to severe stresses from high winds or unusual strains, increase these diameters by from ½ inch to 1 inch. High poles should be of very fine quality. The butts of the poles should be cut off square. The tops should be cut slanting on both sides to form a right-angle "roof." (See fig. 3.)

SELECTION.

Poles should be cut as near the place where they are to be set in line as practicable, but at the same time it should be remembered that it is desirable to use the best and longest-lived timber that can be obtained at a reasonable cost, such as the cedars, redwood, chestnut, and tamarack. In some cases it may be desirable to purchase poles from commercial companies when the cost at the hole will be lessened, as near railroads, or when a better or longer-lived pole can be obtained than can be secured locally from the National Forest. The life of the pole with regard to butt rot at the ground line must be considered rather than the life of the pole above the ground. If suitable timber can not be obtained at a reasonable price, the possibility of creosoting poles obtained locally should be considered.

SKIDDING AND SEASONING.

When a number of poles or braces can be collected at one point as they are cut, and can be distributed along the line at the time of building without undue expense, they should be completely barked and piled tier upon tier with a space of at least 6 inches between poles in the same tier and between tiers. The bottom tier should be of sufficient height from the ground to allow of the free circulation of air under the poles. They should be seasoned at least two or three months. Seasoned poles are lighter and therefore easier to handle, and are usually more durable.

When it is not feasible to collect poles or braces at one point they should be peeled and raised off the ground or leaned against trees or rocks in an open position to season. Sound dead timber need not be seasoned.

PRESERVATIVE TREATMENT.

Some forethought must be used in deciding on preservative treatment, since it is desirable to treat poles only where it is good common-sense business policy. There are several methods of treatment given in Service publications.[1] Before treatments are undertaken the district forester should be consulted. If poles are to be treated by the brush method, the work should be done according to the following general directions:

Only seasoned poles should be treated. Under no circumstances should green timber be treated with preservatives applied with brushes to the outside, since such treatment is seldom effective and in most cases even hastens decay. All adhering bark, including the inner fibrous bark, should be removed from the portion of the pole to be treated; this can best be done with a drawknife. The preservative should never be applied when the surface of the pole is wet from rain, dew, snow, or frost, or when the pole is frozen.

In hot dry weather heat the creosote from 120° to 150° F.; in cold weather heat it to 180° F. This temperature should not be exceeded for brush treatments. In heating the creosote the utmost precaution must be taken to prevent accidents. If the heating vessel is allowed to boil over or if creosote is spilled and allowed to burn on the outside of the vessel, the contents are likely to ignite. When hot creosote is ignited it burns fiercely, but the flames may be smothered. If creosote becomes mixed with water, the mixture boils violently several degrees below the boiling point of water. A convenient outfit for brush treatment consists of a 5 or 10 gallon can or iron pot, a 3-gallon pail, ½-gallon dipper, a 4 or 5 inch wire-bound brush, and a thermometer.

The hot creosote should be applied over the entire end surface of the butt and from the butt to a point 1½ feet above the ground line when the pole is set. All seasoning checks and knot holes must be filled with particular care, and the preservative must be applied as freely as possible without waste, putting on all that the poles will absorb. After an interval of at least 24 hours the pole should be treated with a second coat applied in the same manner. The tops of the poles and the places where the brackets and braces will be attached may also be treated with two coats of hot creosote.

The butts of braces should be treated in the same manner as poles, and in addition two coats of hot creosote may be applied to the slanting top which is to rest against the pole.

[1] Bul. 78, Wood Preservation in the United States; Bul. 84, Preservative Treatment of Poles; Cir. 188, Volatilization of Various Fractions of Creosote after their Injection into Wood; Cir. 191, Modification of the Sulphonation Test for Creosote.

As a general rule it is not necessary to treat the poles of short branch lines not more than 2 or 3 miles long. If the branch lines are constructed at the same time as the treated main line, the poles should, of course, receive treatment. The life of cedar poles is prolonged approximately three years by treatment. Redwood poles do not need a preservative treatment.

BUILDING DIRECTIONS.

LENGTH OF POLES.

The standard pole is 22 feet long and should be used in all but special cases, where longer poles, of lengths to be determined when locating the line, should be used. In case 22-foot poles are not available and shorter poles are, the shorter ones may be used, but only with the approval of the district forester.

The special cases where poles longer than 22 feet will be used are as follows:

(1) Where the spacing of the poles is such that the required sag in the line wire (see " Sag " table, p. 31) would bring the line wire too close to the ground if the 22-foot pole were used.

(2) Where the underbrush exceeds 10 feet in height, use poles that will keep the lowest wire at least 4 feet above the highest brush at the middle of the span.

(3) Where snow is likely to drift to depths exceeding 10 feet, use poles that will keep the lowest wire at least 2 feet above the maximum height of the drift at the middle of the span.

(4) Where it is necessary to grade the line to overcome abrupt changes in level. For example, there should not be an abrupt change from a 22-foot pole to a 45-foot pole, but instead, from a 22-foot to a 30-foot, and then to a 45-foot pole.

(5) Where the line crosses wagon roads or railways, use poles that will keep the lowest part of the lowest wire at least 14 feet above a road and 26 feet above a railway, measured from the middle or highest point of the road or track. Greater heights must be maintained if required by State laws. (See Crossings, p. 35.)

(6) Where necessary to cross over instead of under other pole lines. (See Crossing Foreign Lines, p. 35.)

(7) At the ends of long spans (more than 500 feet) across rivers and canyons, special poles or construction to be determined or approved by the district forester will be used.

DISTRIBUTION OF POLES.

Poles should be delivered at the holes where they are to be set. In distributing the poles care should be taken to select the heaviest ones for use on curves, at corners, at the ends of long spans, and at terminals.

SPACING.

On straight sections poles should be set 176 feet apart, which is 30 poles per mile. Where it is necessary to make any change in the direction of the line, care should be taken to make the change gradually by spreading the curve over as many poles as possible, raking each pole outward to offset the strain of the curve. (For definition of "rake," see Setting Poles and fig. 1.) If sharp bends are unavoidable, proper guys or braces, or both, must be provided. On curves and corners where the pull is from 10 to 30 feet the pole spacing should be reduced to 100 feet. By the term "pull" is meant the distance x. (See fig. 2.) Where the pull is more than 30 feet, the turn should be made on two poles, approximately 100 feet apart, with equal spacings in the adjacent spans on either side.

At right-angle corners the section on either side next to the corner pole should not be over 100 feet in length. Next to spans of from 200 to 300 feet the adjacent sections at both ends should be 100 feet.

On spans from 300 to 500 feet two sections on both ends should be 100 feet. On spans of more than 500 feet special construction is required.

Abrupt changes in the level of the wire should be avoided. In other words, poles should be spaced so as to set them on either side of a high or low point, using long poles, if necessary, to obtain the desired clearance in the span. For example, in crossing a ridge or ravine, it is better to space the poles so that one is set each side of the ridge or ravine rather than to set a pole on the crest or in the bottom.

DIGGING HOLES.

On straight sections holes should be vertical and of full size from top to bottom and at least 6 inches larger in diameter than the butt of the pole. This will permit the earth to be evenly tamped around the pole for the total depth of the hole. Holes should be of the following depths, except on curves or in soft soils, where poles should be set about 6 inches deeper.

Over-all length of pole.	Depth of hole.		Over-all length of pole.	Depth of hole.	
	In earth.	In rock.		In earth.	In rock.
Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
18	3½	3	35	6	4½
22	4	3	40	6½	5
25	4½	3½	45	6½	5
30	5	4			

On a hillside the depth of the hole should be measured from the lowest side of the opening. Where the hillside is so soft that the pole is likely to kick out, the pole should be set as deep as is justified, in the judgment of the foreman in charge.

Where it is not possible to dig the required depth, the hole should be blasted, but where this is not feasible the pole should be securely braced or guyed.

Where the line crosses solid rock the length of spans may be increased up to 300 feet to avoid the expense of blasting holes. Where it is necessary to blast many holes, special construction may be resorted to, and instructions should be asked from the district office before taking up the work.

Where it would be cheaper, notwithstanding the liability to rust, special construction, such as using 2 or 2½ inch wrought-iron pipe for short-length poles, should be considered. Such poles may be fitted into drilled holes, and blasting would be unnecessary. There are several forms of commercial brackets and pins which, by the use of a little ingenuity, may be set into the top of the poles.

LIGHTNING RODS.

Lightning rods should be put on poles before they are set, and in ordinary situations one should be placed on every tenth pole. In exposed, mountainous regions, however, or where the line crosses mountain ranges or divides, one should be placed on every fifth pole. Wire of the same kind as the line should be used. It will be attached to the pole in the following manner: Cut the wire sufficiently long to reach from 6 inches above the top of the pole to about 3 feet below the bottom, which will be sufficient to make a small coil of three or four turns, 5 or 6 inches across, at the bottom of (not around) the pole. The upper end of the wire should be bent back about 3 inches from the end and given several turns about itself. It should then be stapled to the pole with 2-inch staples at a point one-fourth the distance around the pole from the bracket and should run in a straight line down the pole into the ground. The upper end should project about 3 inches above the ridge of the pole, and after the first staple has been driven the wire should be drawn tight and stapled at the bottom. Additional staples should be used at intervals of 3 feet. The wire coiled at the bottom should be bent into place or stapled at the bottom of the pole so that the pole when set will rest on the coils.

After the pole is set and the line wire attached, an inspection will be made to make sure that there can be no contact between the lightning-rod wire and the line wire.

SETTING POLES.

On straight sections poles are to be set vertically. Poles on curves or corners must be set so that they will incline outward from the center of the curve. (See fig. 1.) When the pull is less than 5 feet the rake should be about 10 inches; when the pull is 5 to 10 feet the rake should be about 15 inches; and when the pull is more

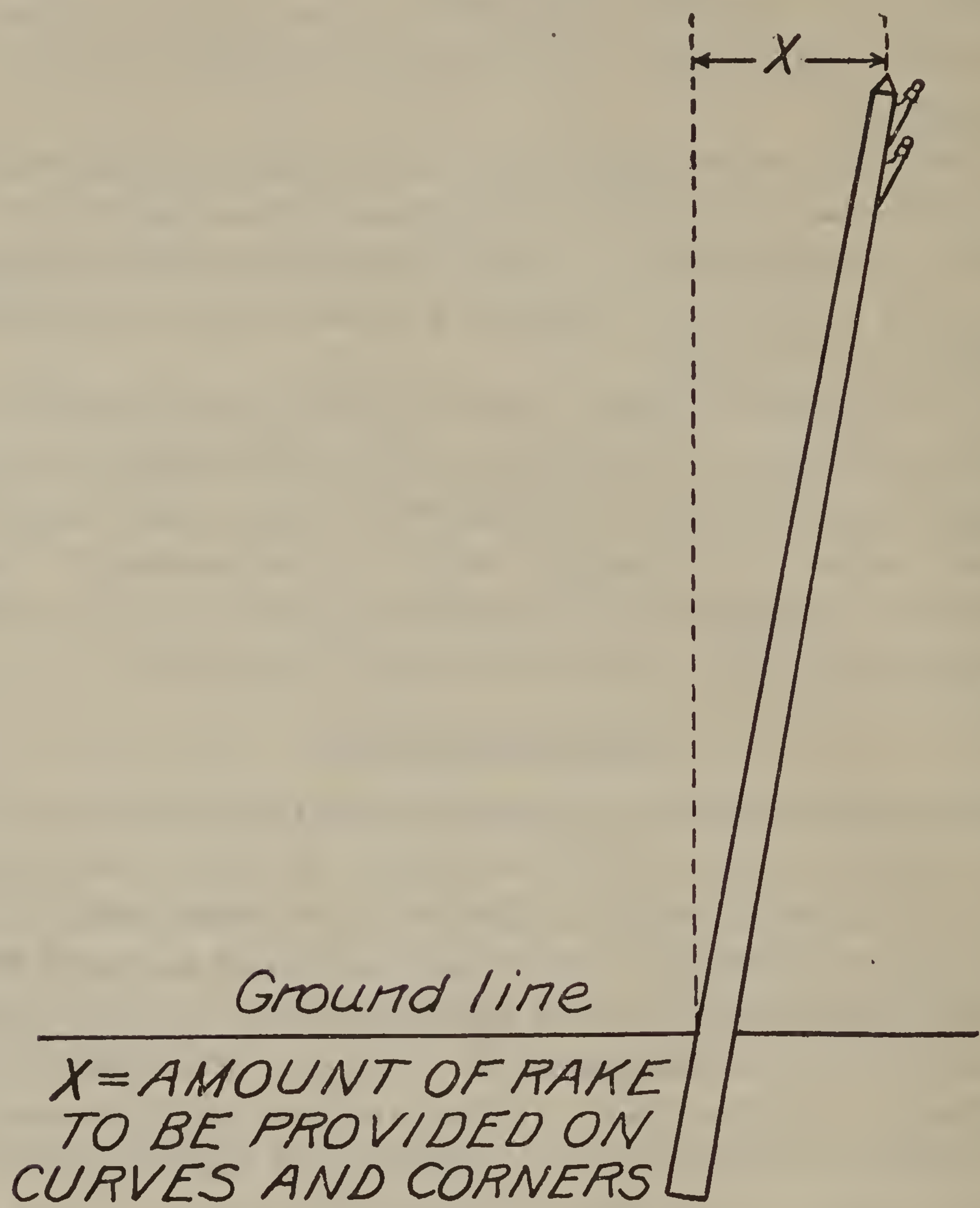

FIG. 1.—Definition of rake.

than 10 feet the rake should be about 25 inches. These figures apply to the top of the pole after it has been set and before the line wire

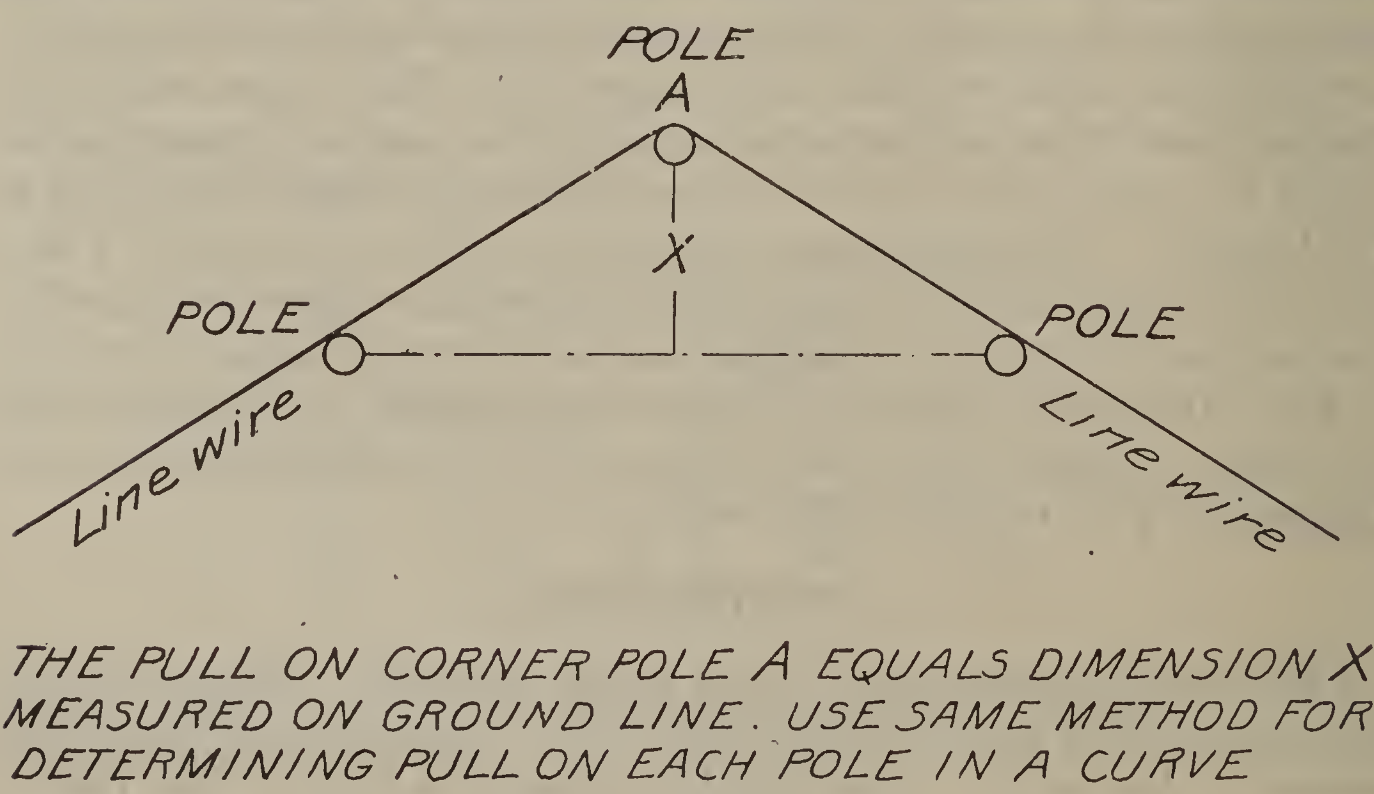

FIG. 2.—Definition of pull.

has been attached. No attention need be paid to the possibility of the line wire changing the amount of rake.

These specifications for rake are approximate and may be exceeded without harm. Rake is sometimes necessary even though the pole is braced or guyed.

Warped or crooked poles should be set so that the crookedness will offset the pull of the line wire at the ends of long spans or on curves or corners.

Poles will be set so that the ridges of their roofs shall be parallel with the line wire.

FILLING AND TAMPING.

In setting the pole it should be " trued " and held in position while the dirt is being filled in evenly around it and thoroughly tamped as the hole is filled. The filling should be done by only one man, and the earth firmly tamped by two men working continuously until the hole is completely filled. When the hole is filled earth should be piled up about 6 inches high around the pole and firmly packed. In filling holes the coarse soil or gravel should be put in last. Poles set in solid rock should have rock fragments firmly wedged in around them.

ATTACHING BRACKETS.

Brackets will be attached and insulators screwed on before the pole is erected. Special care must be taken to see that the brackets are exactly at right angles to the line. Care should be taken in setting the poles to have the bracket in the right position so that the line wire can not touch the pole. It is not necessary to shave the pole where the bracket is attached.

The brackets on a one-wire line should be placed on the same side as the " roof " slant, and on the same side of all poles in the line except that all brackets at corners or curves will be on the side of the poles away from the center of the curve, so that the line wire will pull the brackets against rather than away from the poles. Brackets will be nailed to the pole with one 60-penny and one 40-penny galvanized-iron wire nail. For one-wire lines the top bracket position will be used.

On straight sections of a two-wire line the brackets will be on opposite sides of the poles (see fig. 3), but on curves both brackets will be on the same side of the pole away from the center of the curve (see fig. 3).

Whenever a line crosses the tracks of a railroad, two brackets with insulators placed side by side should be used on the first pole on each side of the track to make a doubly strong fastening so that the wire will be less likely to come down across the right of way. Two brackets slightly separated may be employed where a line is attached to a large tree or large pole at a sharp corner, so as to keep the line wire well clear from the pole or tree.

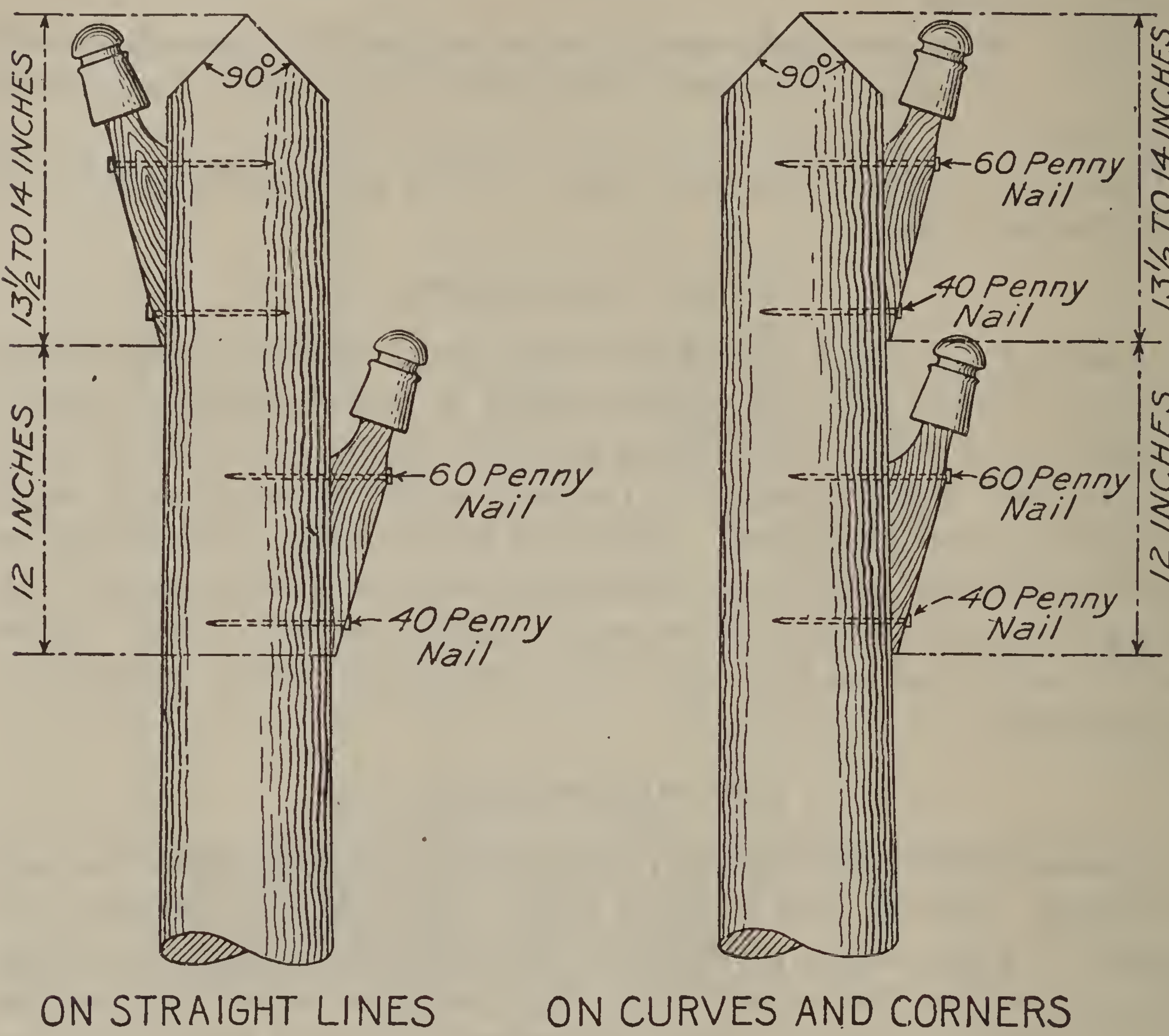

FIG. 3.—Location of brackets on pole.

BRACING AND GUYING.

Where it is cheaper to use braces than guys, braces should be used. A proper amount of rake does away with most of the cases where bracing or guying would otherwise be needed. However, braces or guys should be used in the following cases:

(*a*) On any pole on a curve or at a corner where the pull on the pole exceeds 30 feet.

(*b*) On poles at each side of a crossing over roads and railroad rights of way.

(*c*) On the two end poles of spans between 300 and 500 feet.

(*d*) On the poles at either end of spans above 500 feet (special construction).

(*e*) On very steep slopes. Anchor guys may preferably be used in these cases, or a head guy from the top of one pole (below the lowest bracket) to the base of the pole next above it may be used.

(*f*) On alternate poles in exposed positions.

(*g*) On poles in swamps or on loose ground, where necessary.

(*h*) On poles on both ends of high tension transmission line crossings.

(*i*) On the first and last poles of a line.

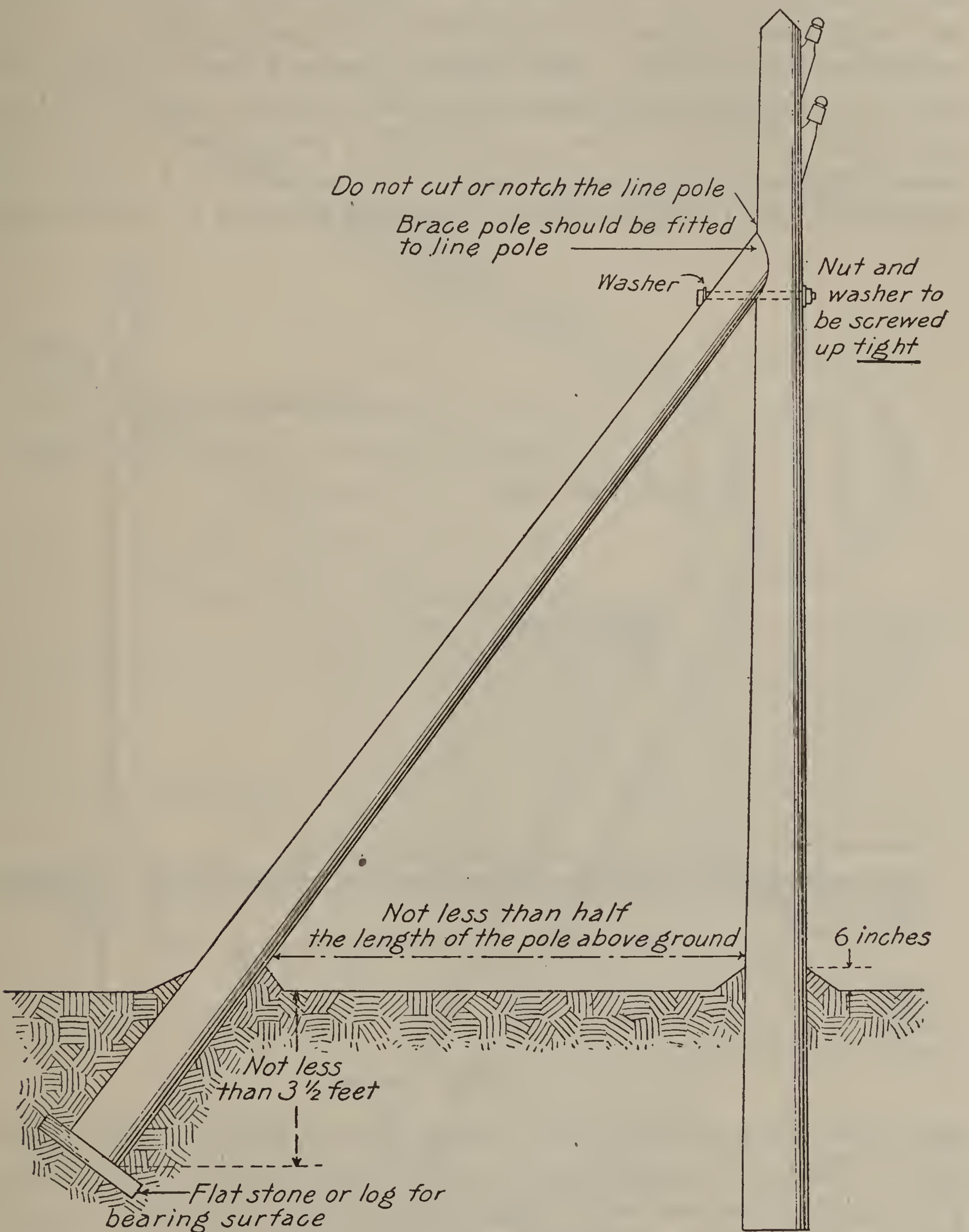

Fig. 4.—Method of bracing.

When a guy is to be put up on a public highway or street in city or town, a guard of some kind should be wired to the guy, in order that it may be easily seen. The guy wire may be boxed up to a height of 6 feet above the ground, or a sapling about 3 inches in diameter may be wired to it.

BRACES.

Braces (see fig. 4) should be at least 8 inches in diameter at the butt end and should be cut slanting at the top to fit close to the pole, but the pole itself must not be cut. They should set at least $2\frac{1}{2}$ feet in the ground; $3\frac{1}{2}$ feet would be better, if too much difficulty is not encountered in digging. The distance between the brace and the pole, as measured on the ground, should be not less than one-half of the height of the pole above ground. The bottom end of the brace should rest on a flat stone or piece of log or plank. A $\frac{5}{8}$-inch hole should be bored through both the brace and the pole to pass through

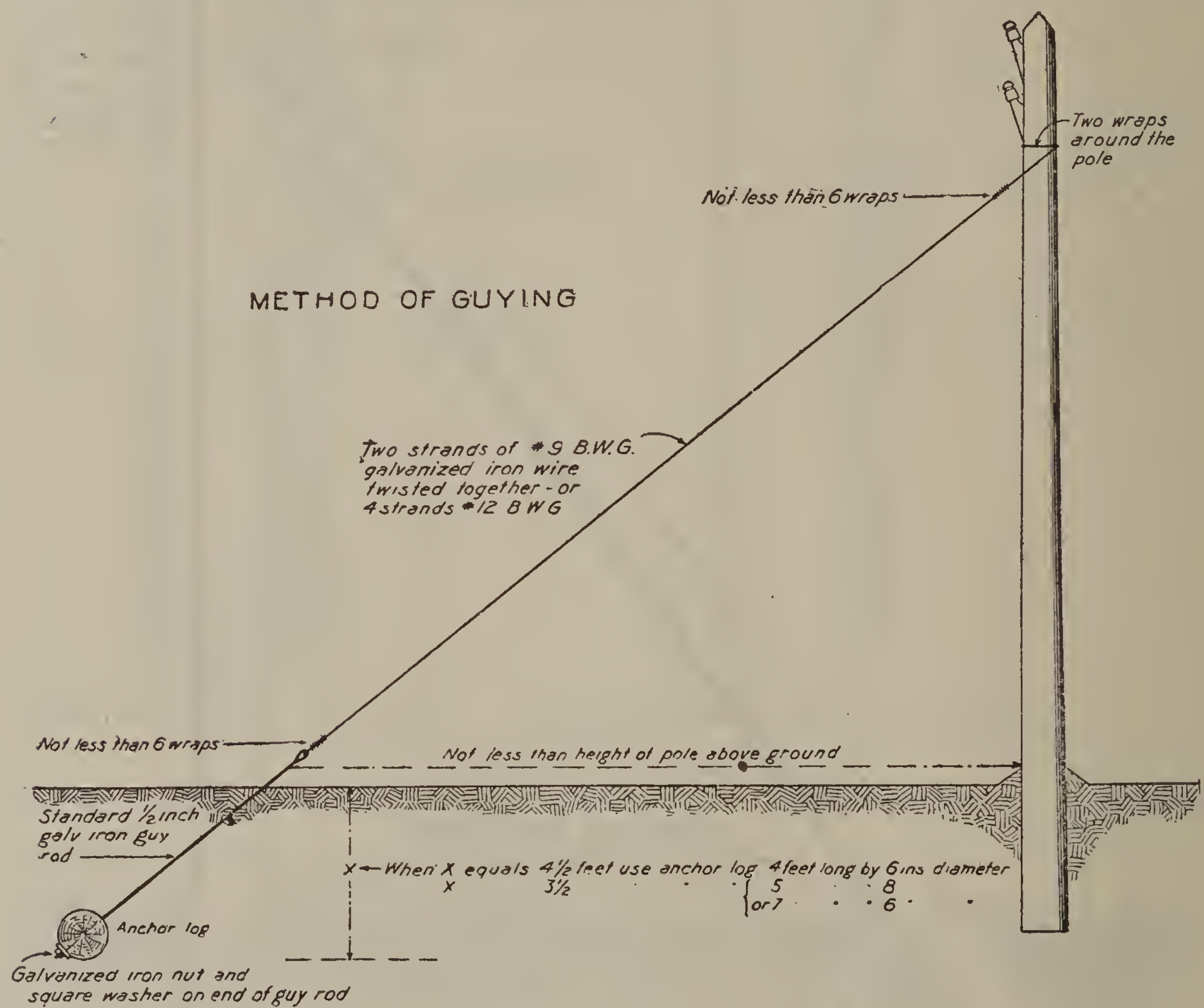

FIG. 5.—Method of guying.

just above the point where the bottom edge of the brace touches the pole. The brace should then be bolted tightly to the pole with a $\frac{5}{8}$-inch galvanized-iron bolt, using a $2\frac{1}{4}$ by $2\frac{1}{2}$ by $\frac{3}{16}$ inch galvanized-iron square washer under both the head of the bolt and under the nut.

GUYS.

A guy (see fig. 5) should be made of two pieces of the line wire (No. 9 BWG) twisted together, and should be long enough to reach from the top of the pole below the lowest bracket to the ground, at a distance away from the bottom of the pole equal to the height of the pole above ground, with enough additional length to allow for going through the eye of a standard half-inch galvanized-iron guy rod, and for wrapping the end of the guy wire twice around the pole and securing the ends. After a guy is twisted up and ready to be put in

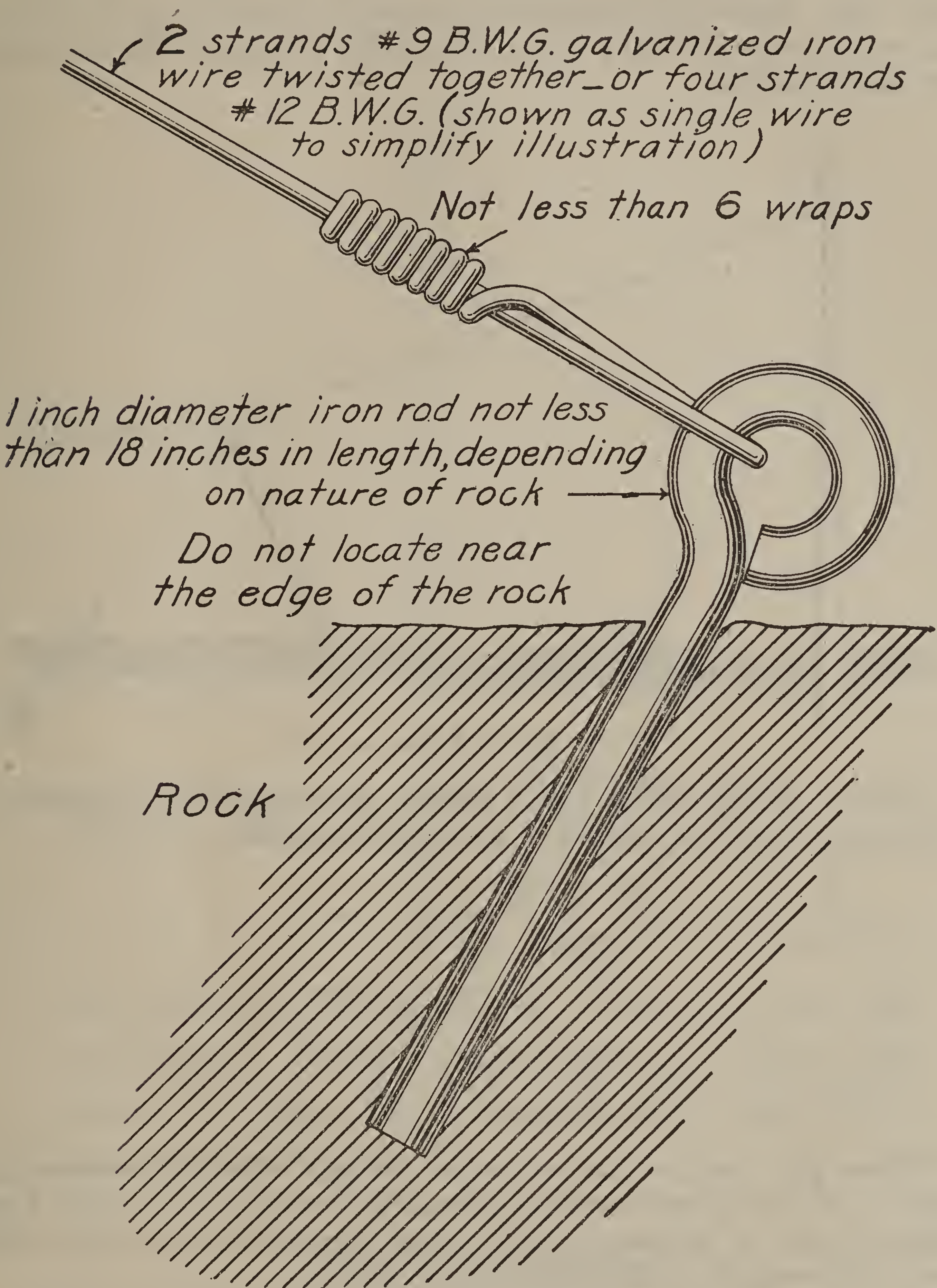

FIG. 6.—Rock guy bolt.

place, one end should first be wrapped around the pole twice, stapled, and the loose end secured by not less than six wraps around the guy wire itself, with a pair of connectors or pliers. The anchor log is then placed in the ground with the guy rod passing through it. The eye of the guy rod should project above the ground. One of a pair of pulley blocks is then hooked into the eye and the other is fastened to a Buffalo grip or a medium-sized Haven clamp attached to the guy wire. The guy is then pulled to the required tension, and the end of the wire looped through the eye and secured by not less than six wraps around the guy wire. The pulley blocks and Buffalo grip are then removed.

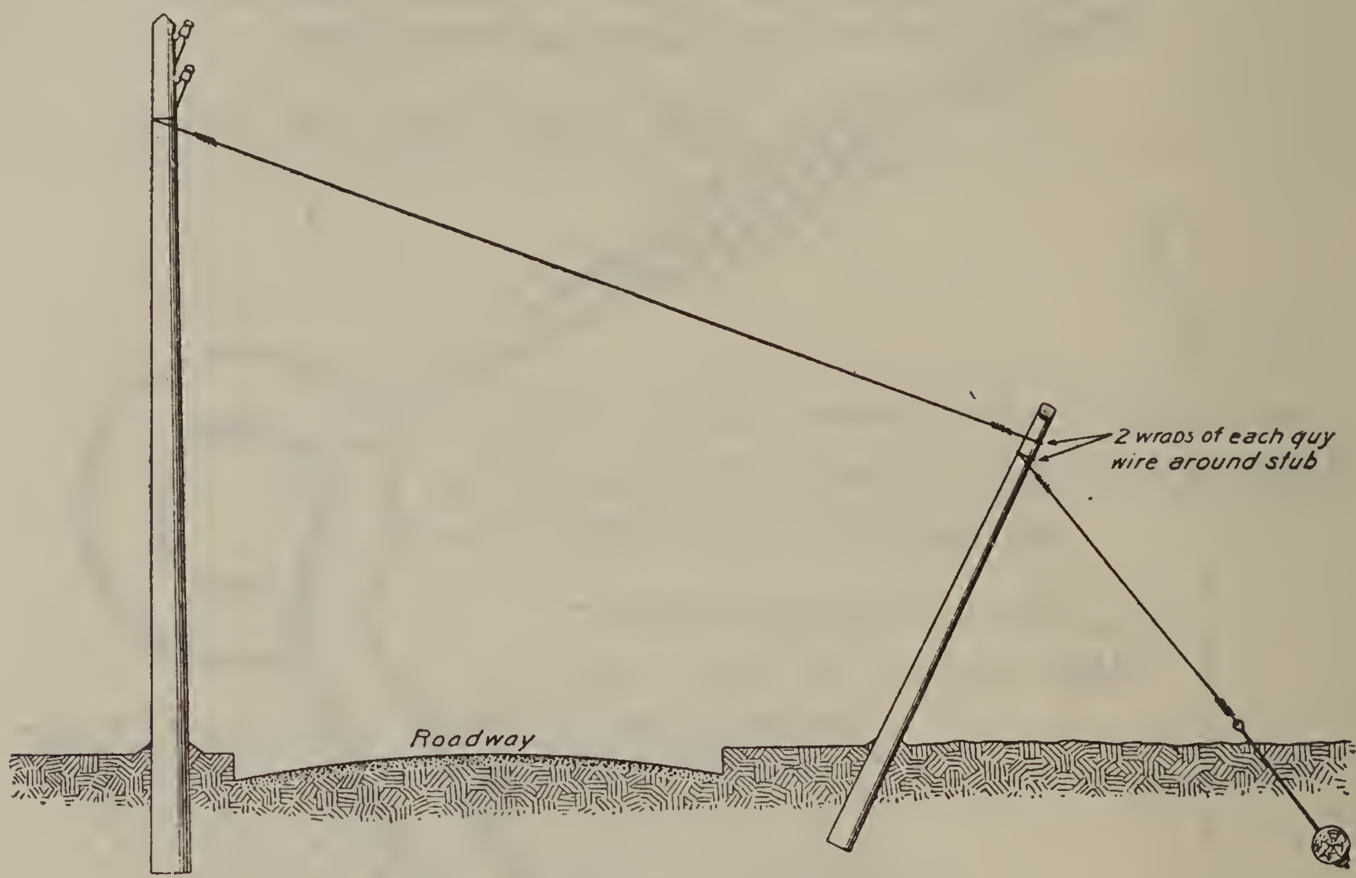

Fig. 7.—Method of using guy stub.

The size of the anchor log is usually determined by the depth to which it is buried, according to the following table:

Depth of excavation.	Dimension of anchor log.	
	Length.	Diameter.
Feet.	*Feet.*	*Inches.*
4½	4	6
3½	5 or 7	8 or 6

Where guy rods are not available, the guy wire will necessarily have to be run down into the ground and around the anchor log, although this is temporary construction, because the guy wire will rust and break off at the surface of the ground.

TREE GUYS.

Where a live tree of large diameter is near by, the guy wire may be anchored to it instead of to a buried anchor log, providing hardwood slats are used between the guy wire and the tree to prevent injury to the tree.

ROCK GUYS.

A home-made iron eyebolt 1 inch in diameter by not less than 18 inches long may safely be used for anchoring the guy wire in rock. The angle formed by the guy wire and the shank of the bolt should not be more than 90° or a right angle. (See fig. 6.) The bolt should not be near the edge of the rock or ledge.

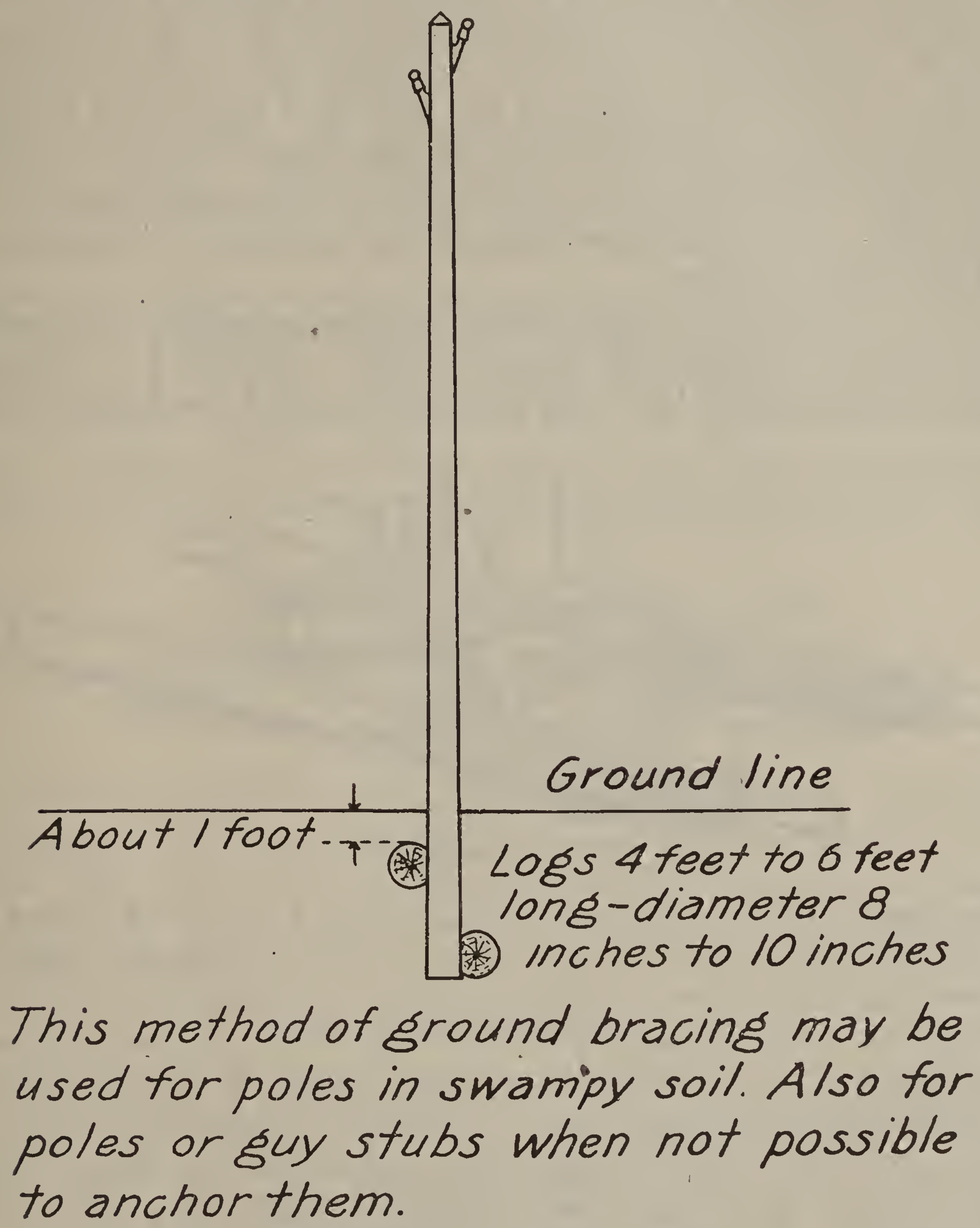

FIG 8.—Method of ground bracing.

GUYING ACROSS ROADS.

When a road interferes with the ordinary method of guying, a guy stub should be used (see fig. 7) so as to give proper clearance for traffic. The guy stub should be guyed with the standard guy rod and anchor log, but when this is not possible it should be braced with anchor logs underground as shown for the pole (see fig. 8).

SWAMPY SOIL.

In swampy soil poles may need to be braced with anchor logs under ground, as shown in fig. 8.

STRINGING WIRE.

The wire may be pulled out a half mile at a time by a horse, using a rope that can instantly be let go between the ends of the wire and the traces of the horse. Or it may be pulled out by three men, with one man stationed at the payout reel to stop it from going too fast, or to signal in case the wire kinks or gets tangled on the reel. The payout reel handled by the supply houses is of hardwood bound with iron straps. Its weight precludes its use on lines following trails and through the timber.

A home-made reel is much lighter and less expensive. It consists of two parts, a support and the reel proper. (See fig. 9.) The support is made of two 2 by 4 inch pieces, *AA*, each 5 feet long and held

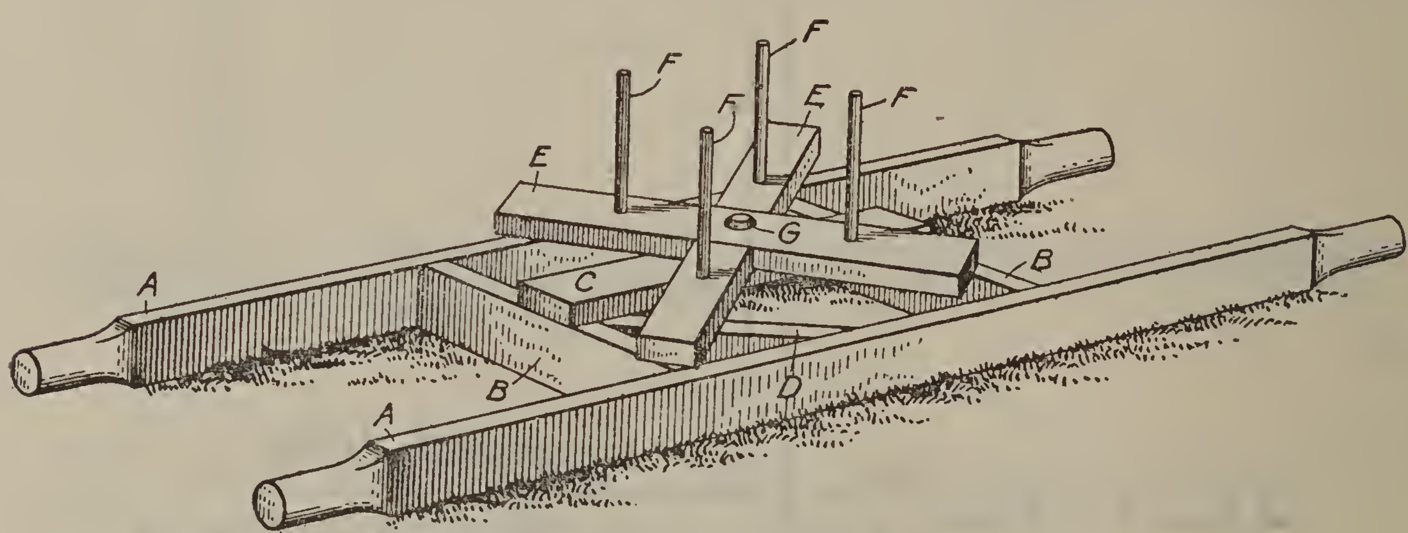

FIG. 9.—Home-made reel.

2 feet apart by two cross pieces, *BB*, of 2 by 4 inch stuff, nailed between, and 1 foot each side of the center of the long pieces. Midway between the long pieces and fastened to the cross pieces is a 2 by 4, *C*, through the center of which a ½-inch hole is bored. To secure greater rigidity a 2 by 4, *D*, is mitered to fit from the center of one side to the center of one of the cross pieces. The reel is made of two pieces of 2 by 4 stuff, *EE*, 2 feet 9 inches long, and mortised to the middle to form a cross. After these have been fitted together a ½-inch hole is bored through the center, and 9 inches from this center, on each arm, a ½-inch bolt, *F*, 10 inches long, is set upright, the four to fit inside a coil of wire. A ½-inch bolt, *G*, dropped through the center of the reel and of the support, completes the outfit. The cost of the whole apparatus is so small that it may be discarded, if necessary, when the work is completed.

Another and probably the most satisfactory method in National Forest work is for two men to carry the reel, paying out the wire as they go. This requires but a small amount of time each day, and two men from the swamping gang could be used. In suitable country the reel can be placed in the rear of a wagon and paid out much faster. Special precaution should be taken in paying out the wire to make sure in advance which side of poles or trees it should go, in order to avoid the necessity of cutting the wire to correct mistakes, as it is absolutely essential that the number of splices be kept at a minimum.

No more wire should be strung out than can be put up and tied during one day. Special care should be taken not to reel off wire and allow it to lie across trails or roads where it will be run over by vehicles or animals; for aside from the danger, the wire may be kinked or nicked. While the wire may not break at the time, it will be weakened sufficiently to break as soon as a little strain is put upon it or when it contracts in cold weather. Care must be taken that all kinks are straightened before it is stretched. With hard-drawn copper wire all kinks or deep nicks must be cut out and a splice made at that point. In fact, hard-drawn copper wire must be handled much more carefully than galvanized-iron wire. It should not be thrown from a wagon to the ground in the coil, and before attempting to unreel it the first 15 or 20 loops of the coils should be carefully lifted

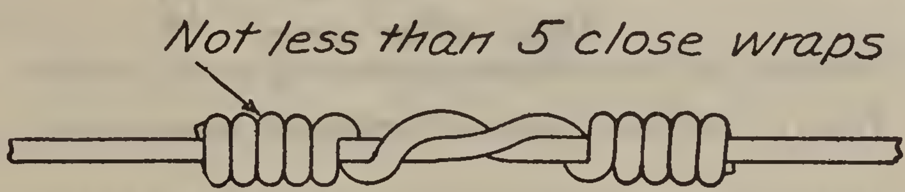

FIG. 10.—Method of splicing iron wire (Western Union joint).

up by hand to make sure that there are no "cross-overs." This same practice may well be followed before unreeling galvanized-iron wire.

For spans up to 500 feet the galvanized-iron wire may be used,[1] but for longer spans steel wire or other forms of special construction will be necessary.

SPLICING WIRE.

In the construction of all lines in the future, splices in galvanized-iron wire should be made by the use of the standard Western Union joint. (See fig. 10.) For hard-drawn copper wire a standard double-tube copper sleeve should be used (see fig. 11); galvanized-iron sleeves must not be used. Copper sleeves will not be used for

[1] If the circuit is of No. 12 N. B. S. G. hard-drawn copper wire and it is necessary to make spans longer than 300 feet, No. 8 B. W. G. hard-drawn copper wire shall be used for the spans from 300 to 500 feet. No. 12 N. B. S. G. hard-drawn copper wire should not be used on spans longer than 300 feet.

If the circuit is of No. 14 N. B. S. G. hard-drawn copper wire and it is necessary to make spans longer than 200 feet, No. 12 N. B. S. G. hard-drawn copper wire shall be used where the span is from 201 to 300 feet, and No. 8 B. W. G. hard-drawn copper wire shall be used where the span is from 301 to 500 feet. No. 14 N. B. S. G. hard-drawn copper wire shall not be used on spans longer than 200 feet.

splicing galvanized-iron wire, because the corrosion which these sleeves cause on galvanized wire results ultimately in a high resistance joint which may become the equivalent, electrically speaking, of several miles of extra line. When copper sleeves are used for joining hard-drawn copper wire, they shall be twisted not less than three nor more than four turns with a pair of reversible connectors of the No. 309 type. In ordering sleeves it is necessary to specify the size of the wire for which the sleeve is required. The ends of the wire should project approximately 1 inch from the end of the sleeve before twisting. After the sleeve is twisted the protruding ends of the wire should be cut off not closer than one-half inch and should be bent back slightly on the sleeve.

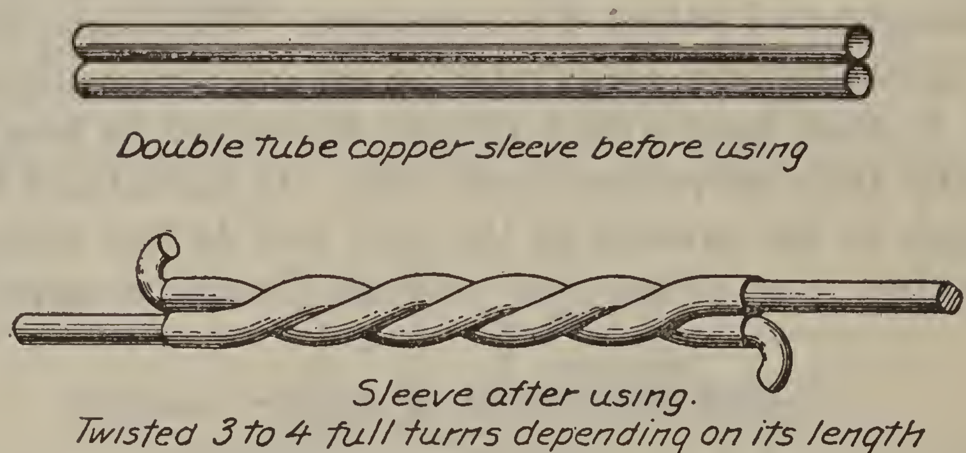

Fig. 11.—Method of splicing hard-drawn copper wire.

In making joints every precaution should be taken to prevent nicking the wire, whether galvanized iron or copper.

TYING IN WIRE.

GENERAL.

On straight sections and on curves and corners the line wire should be attached on the outside of the insulator; that is, the insulator will be between the line wire and the pole. (For regular tie see fig. 12.) In crossing railroad rights of way, however, or well-traveled public highways, the line wire should be attached on the inside of the insulator, or between the insulator and the pole. If the line should become untied it will then fall between the bracket and the pole and not across the right of way. Where necessary, the wire may be kept on the outside for a specific reason, such as a curve or corner at such a crossing. Linemen should be cautioned against nicking the line wire in making ties, especially where hard-drawn copper wire is used. Hard-drawn copper wire should always be tied by hand pliers, connectors, or other tools. Linemen should also be cautioned against leaving the ends of the tie wire protruding, lest they might come in contact with the pole if the pole should ultimately become twisted around.

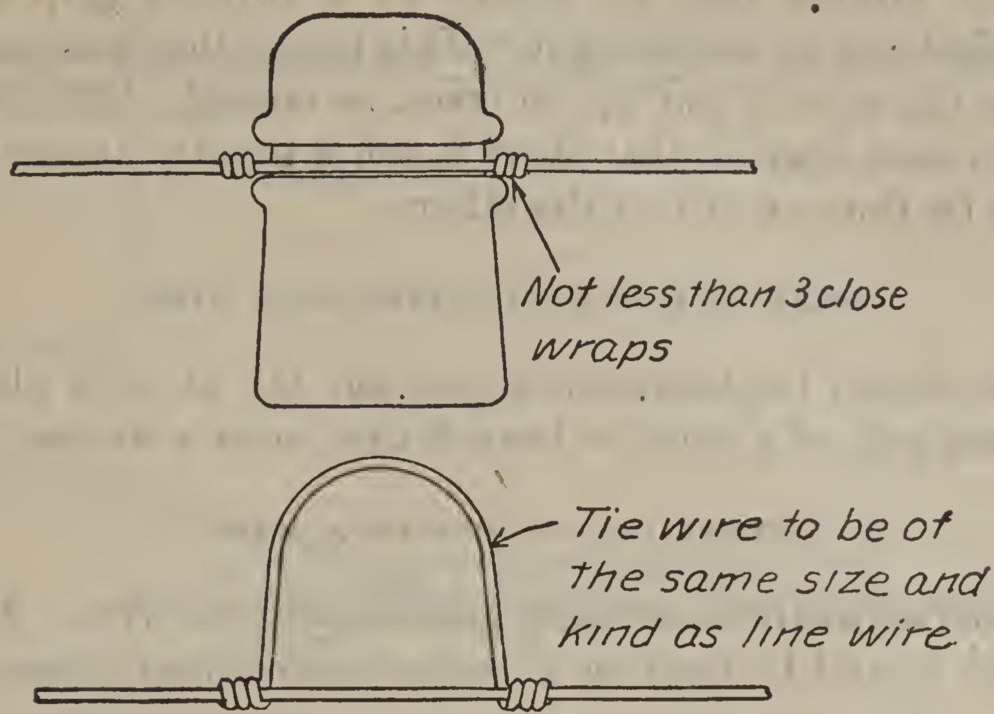

FIG. 12.—Method of making regular tie for iron wire.

When tying in a line that is attached to poles (not trees) and the work is stopped for a short time, or at the end of the day,

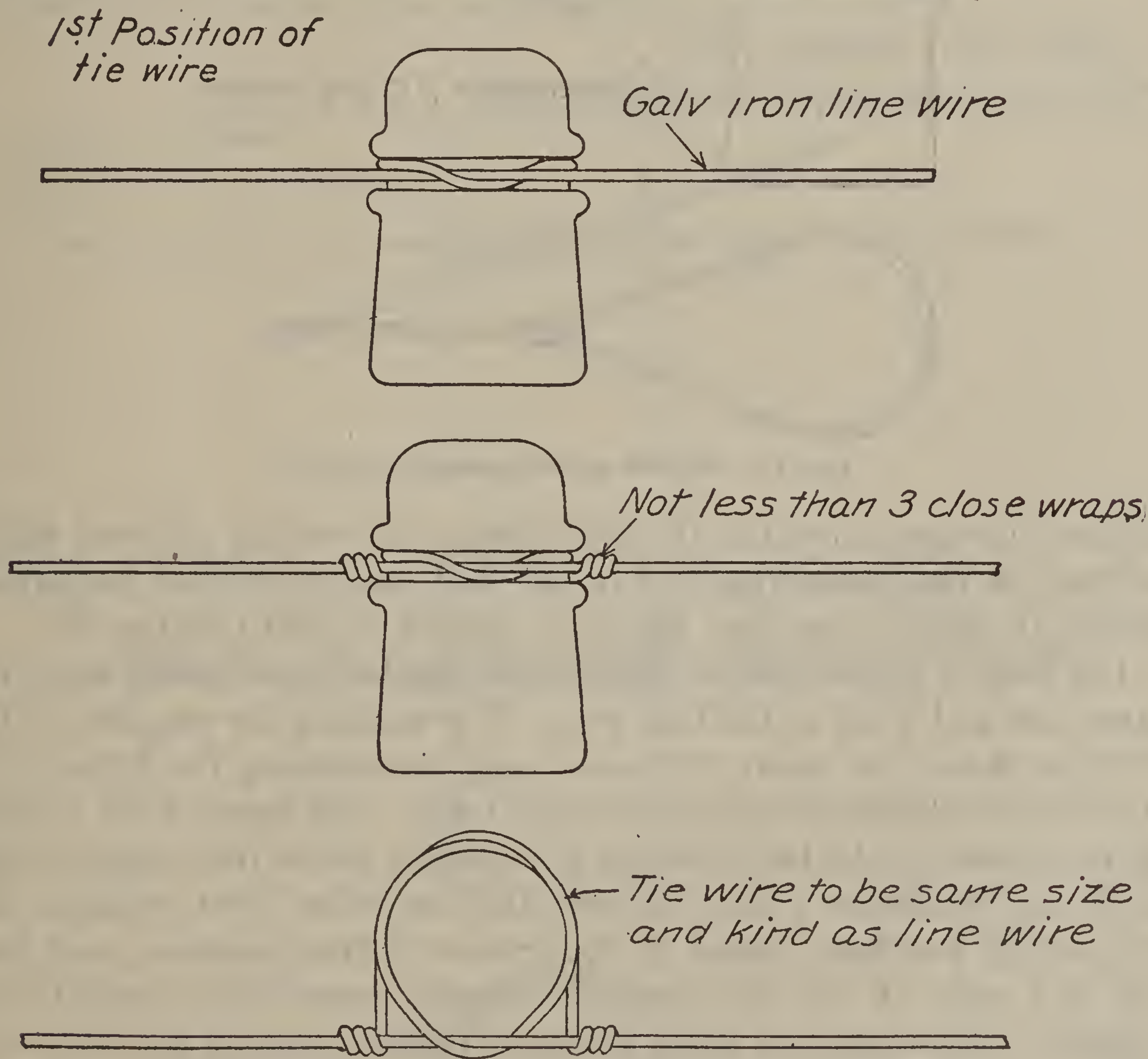

FIG. 13.—Method of making "figure 8" tie for iron wire.

the last tie put on should be a figure 8 tie. (See fig. 13.) The line wire should then be continued on over the bracket of the next pole, without being tied, and brought down and anchored to the butt of the next farther pole by means of a Buffalo grip and either stretcher blocks or by snubbing it. This precaution will not be necessary where the wire is put up on trees, as enough slack should have been left in each span so that there is not a greater amount of strain on the last tie than on any of the others.

DEAD-ENDING GALVANIZED-IRON WIRE.

The line should be dead-ended (see fig. 14) at such places as the first and last pole of a main or branch line, or at a station.

TYING GALVANIZED-IRON WIRE.

There are two methods of tying galvanized-iron wire. The regular tie (fig. 12) should be used on all poles except where there are sharp

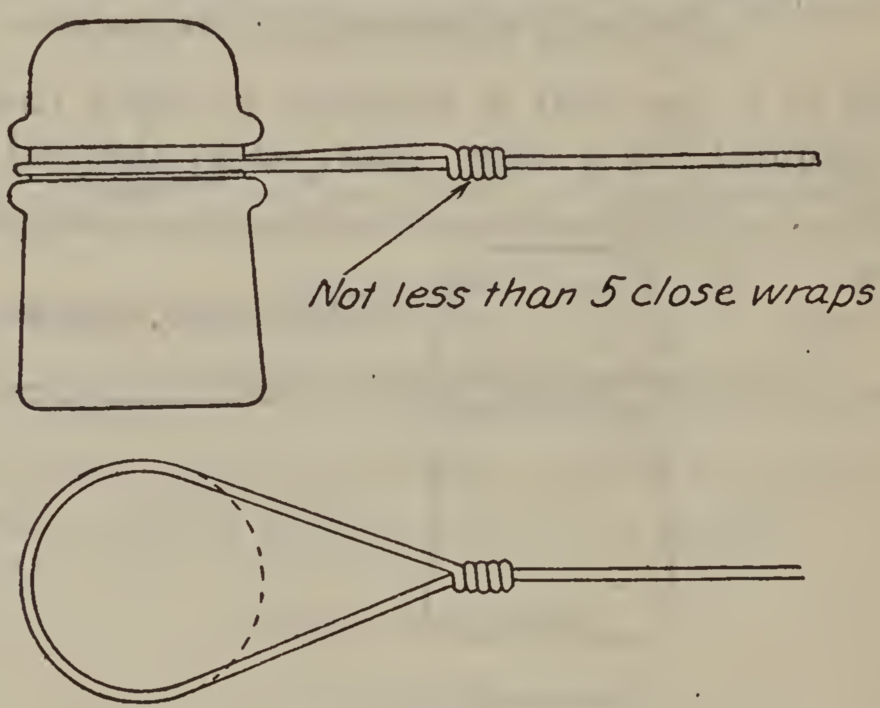

FIG. 14.—Method of dead-ending iron wire.

dips or changes in level in the line wire, or in crossing railroad rights of way, or on spans from 250 to 500 feet, and at similar important points, in which cases the "figure 8" should be used (see fig. 13).

For both a regular and a figure 8 tie the tie wire should be of the same size and kind as the line wire. For making the regular tie the tie wire should be about 16 inches long; for making the figure 8 tie the tie wire should be about 30 inches long. The figure 8 tie is made by first bending the tie wire into a horseshoe shape just large enough to fit the insulator, putting it over the line wire (first position, fig. 13), which has been placed in the groove of the insulator, and then the two ends of the tie wire are brought around the insulator in opposite directions and then wrapped tightly around the line with not less than three wraps, as close together and as tight as possible, using pliers or connectors for the purpose.

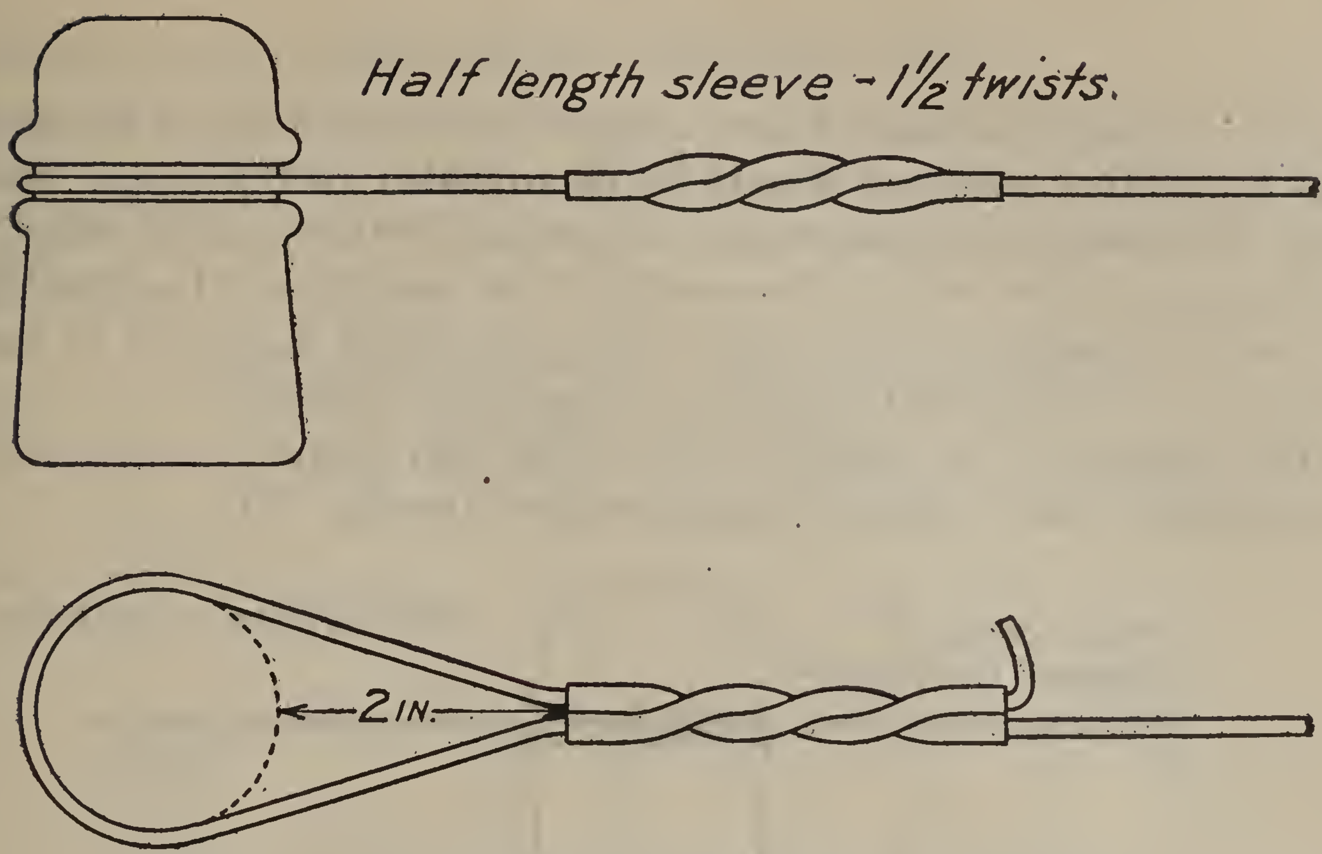

FIG. 15.—Method of dead-ending hard-drawn copper wire.

DEAD-ENDING HARD-DRAWN COPPER WIRE.

Hard-drawn copper wire is dead ended (see fig. 15) by the use of a half-length double-tube copper sleeve.

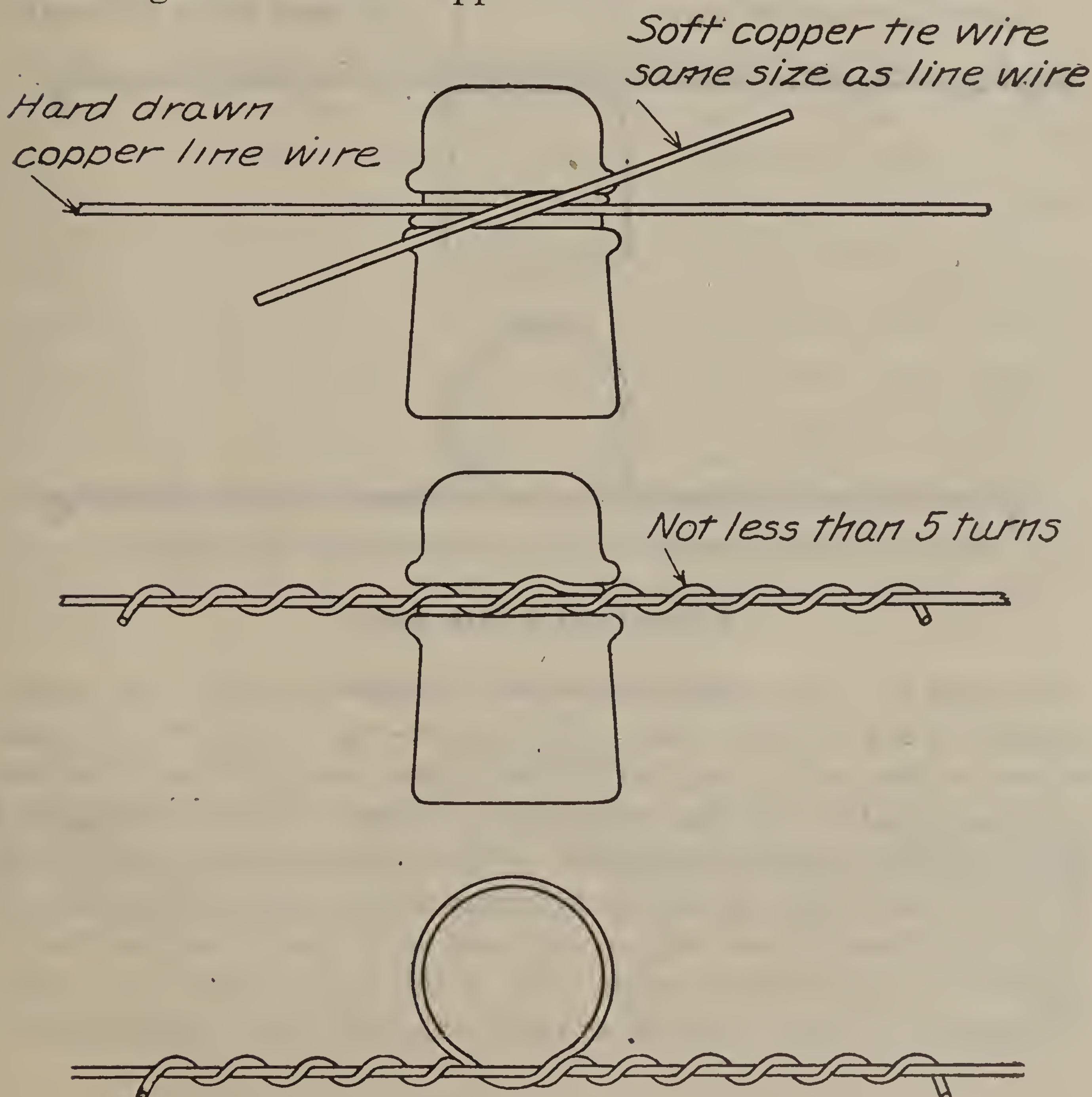

FIG. 16.—Method of making regular tie for hard-drawn copper wire.

TYING HARD-DRAWN COPPER WIRE.

All tie wires for hard-drawn copper wire should be of the same size as the line wire, but should be of annealed (soft) copper wire. Soft tie wires may be purchased in bundles, or they can be made by cutting up the line wire and annealing it by heating and then cooling it slowly to make it less brittle. Care should be taken not to heat the wire too hot, so that it pits, or to cool it too quickly.

The regular tie for copper wire (see fig. 16) should be used in all cases except where a figure 8 tie is required (see fig. 17).

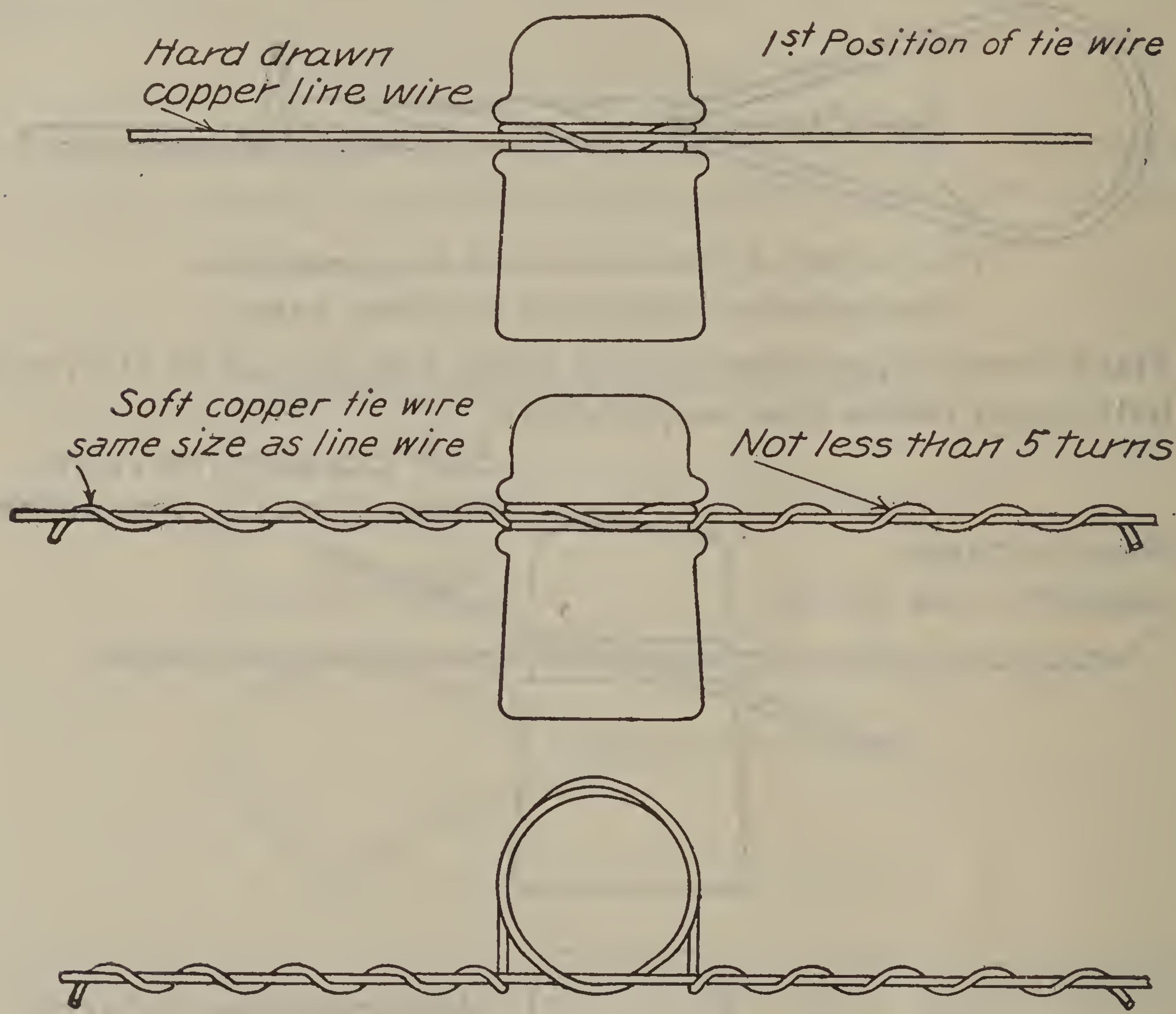

FIG. 17.—Method of making "figure 8" tie for hard-drawn copper wire.

ALLOWANCE FOR SAG.

In tying in a line due care should be taken to allow the proper amount of sag in each span. Much more sag is required in spans between a pole and a tree than between poles, and still more between two trees, to allow for the swaying of the trees. The following sag table should be used for pole lines. This table is drawn up for No. 12 B. W. G. and No. 9 B. W. G. galvanized-iron wire and for No. 12 N. B. S. G. hard-drawn copper wire and may also be used for No. 14 N. B. S. G. hard-drawn copper wire if the sag is increased 2 inches in each case. There must be as much sag left in the line wire as is provided by this table; there must not be less. It is particularly important that Forest Service pole lines be given the proper sag because they are exceptionally exposed to sleet and ice, to falling timber, and to severe contractions at the low temperatures found in high altitudes.

TABLE 1.—*Sag of wire when line is strung upon poles.*[1]

[Temperatures in degrees Fahrenheit.]

Length of span.	Sag at—													
	+100°		+80°		+60°		+30°		+10°		−10°		−30°	
	Ft.	*in.*	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*
75 feet...		4½		3		2½		2		1½		1½		1
100 feet..		7		5½		4½		3½		3		2½		2
115 feet..		9		7		5½		4		3½		3		2½
130 feet..		11		8½		7		5½		4½		4		3½
150 feet..		14		11½		9		7		6		5		4½
176 feet..		18		15		12		9½		8		7		6
200 feet..		22½		19		16		12		10½		9		8
260 feet..		39½		34		29½		23		20		17½		15
300 feet..		55		49		42½		33		29½		25½		22
350 feet..	6	6	5	6		59		46		41		36		31
400 feet..	8		7		6	6	5			54½		48½		43
450 feet..	10		9		8		6	6	6		5	6	5	
500 feet..	12	6	11		9	6	8		7	6	7		6	

[1] For table on sag required where swinging insulators are used, see p. 32.

Sag may be handled in the following manner: After a half-mile reel of wire has been pulled out along the pole line linemen who follow carry the wire up each pole on their shoulders and lay it between the bracket and the pole. As soon as this has been done over the entire half mile the line is then stretched by means of a Buffalo grip and stretcher block until it is taut or until the two or three linemen who are up on the poles, back along the half mile, pass along the signal to stop. About two minutes' rest is then required for the line wire to "creep" along the half mile. It should then be loosened or stretched tighter according to the signals of the men on the poles, who can sight from the bracket of one pole to the brackets of the adjacent poles and signal when the proper amount of slack has been provided.

SPECIAL CONSTRUCTION.

TREE LINES.

Wherever special conditions necessitate the use of trees for supporting the wire, the sag must be considerably more than on a pole line and not less than indicated in the following table:

TABLE 2.—*Sag of wire when swinging insulators are used.*

[Temperatures in degrees Fahrenheit.]

Length of span.	Sag at—													
	+100°		+80°		+60°		+30°		+10°		−10°		−30°	
	Ft.	*in.*	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*
75 feet...		28½		27		26½		26		25½		25½		25
100 feet..		31		29½		28½		27½		27½		26½		26
115 feet..		33		31		29½		28		27½		27		26½
130 feet..		35		32½		31		29½		28½		28		27½
150 feet..		38		35½		33		31		30		29		28½
176 feet..		42		39		36		33½		32		31		30
200 feet..		46½		43		40		36		34½		33		32
260 feet..		63½		58		53½		47		44		41½		39
300 feet..		79		73		66½		57		53½		49½		46
350 feet..	8	6	7	6	7		6		5	6	5			55
400 feet..	10		9		8	6	7	6	7		6		5	6
450 feet..	12		11		10		8	6	8		7	6	7	
500 feet..	14	6		13	11	6	10		9	6	9		8	

Where it is advisable to use trees for supporting the wire, the sag must be considerably more than in a pole line and not less than indicated in Table 2. Not only must there be more sag, but the sag must be distributed through the use of special insulators which allow the wire to slip through and thus distribute the sag over several spans. Yet in order that the slack may not all run to one span the line should be fastened at intervals to fixed glass insulators on brackets at about every seventh tie except where the topography demands more frequent fixed ties. Sufficient slack should be left so that the wire in any span may be forced to within a foot or two of the ground without difficulty. Good judgment and great care are required in selecting the trees to support the line, and also in selecting the tying place on each tree and the method of tying. Only sound trees should be used, with diameters large enough to minimize the swaying, and the course of the line may be varied to take advantage of trees whose use will lessen cost of construction; yet there should be no hesitancy about using poles in a tree line if suitable trees are not available. In tree lines the spans should not exceed 175 feet, and may be as much shorter as desired. They should not be higher than pole lines.

SPLIT TREE INSULATORS.

When lines are fastened to trees, a split tree insulator (fig. 18) is used; a one-piece insulator or knob should not be used. This swinging insulator, to which the wire is not fixed, will permit of a tree falling across the line and carrying it to the ground without breaking it.

The idea of using the swinging insulators is that if a tree falls across the wire and carries it to the ground the wire will not be broken. No. 12 wire should be used for tying to the glass insulators and for every third tie to swinging insulators, so that if more than one tree falls across the line between two fixed glass insulators then the No. 12 wire on a glass insulator or on one of the swinging insulators, being weaker than the No. 9 line wire, will break and allow the line wire to go to the ground without breaking. Every third tie on the swinging insulators is of No. 12 wire; the other two of the three are of a stranded wire known as No. 18 galvanized seizing strand, comprised of seven strands of double galvanized wire. Its use removes the difficulty of crystallization which would follow the working up and down of the ordinary tie wire. The most satisfactory method so far discovered for attaching the tie wire to the tree is by the use of a 3-inch steel or wrought-iron staple.

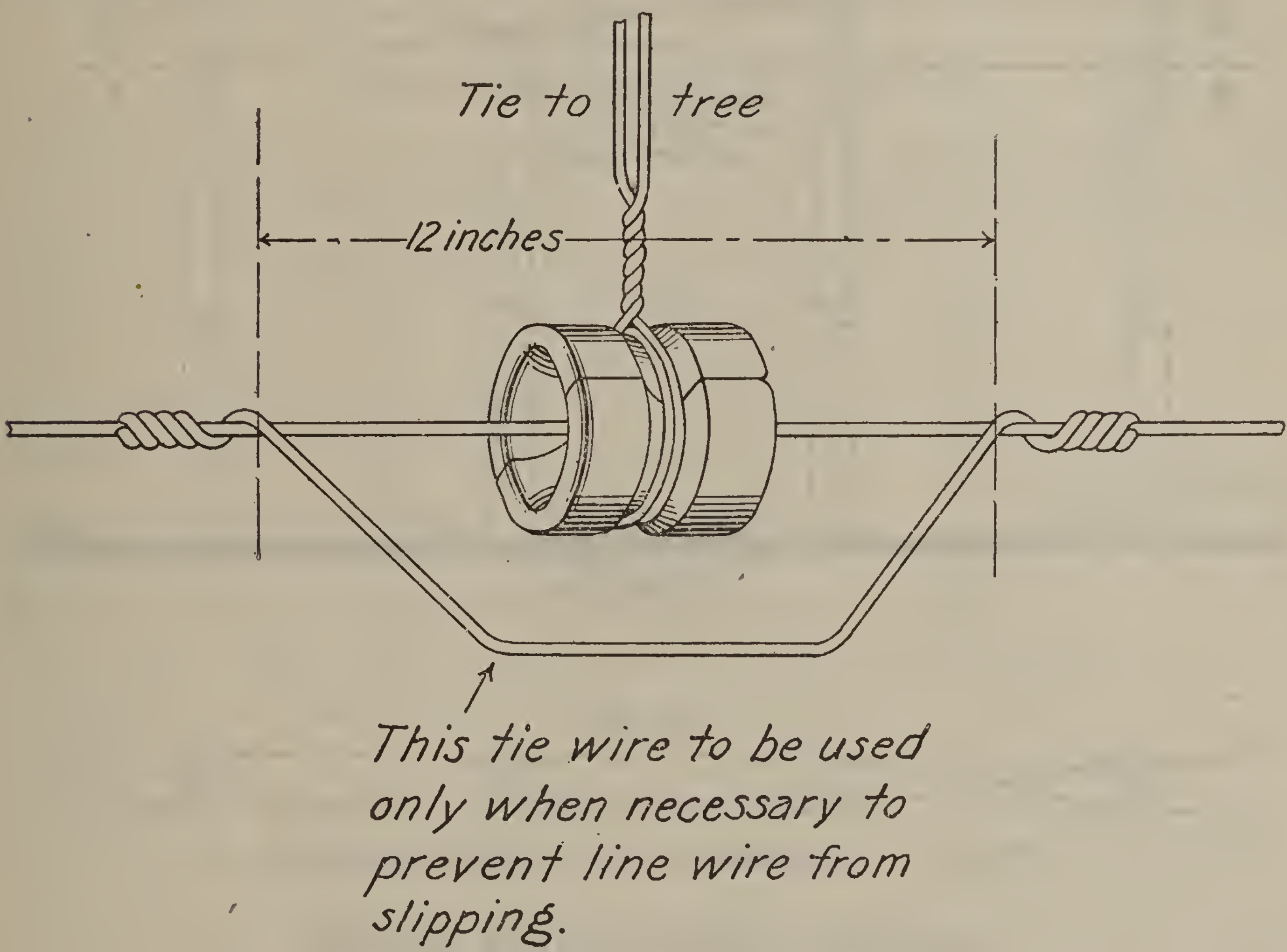

Fig. 18.—Swinging split tree insulator.

TRANSPOSING OF METALLIC CIRCUIT.

When building a metallic circuit, which is a 2-wire line, the wires must be transposed once every mile. By transposition is meant the changing of the location of each wire from one side of the pole to the other (see fig. 19), and the transposition must be so done that the wires will not touch each other where they cross over. Where the line parallels, or is close to, a high-tension transmission line, or in altitudes where the static electricity would interfere, or where it is on poles which carry other wires, it should be transposed at least every tenth pole. The rule for transposing telephone lines is to have the wire on the left always cross over the wire on the right; never under it. On a bracket line the transposition can be made very easily by changing the location of the brackets on the pole, as shown by the upper diagram in figure 19. When the wire is unreeled care should be used to see that transpositions are arranged for at that time. This avoids having to resort to splices for making the transpositions at the time the wires are tied to the insulators. In other words, as the wire is strung out on the ground the left-hand wire crosses over on top of the right at the point where the line is to be transposed. Where a cross-arm is used, transportations can best be made by using a standard two-piece transportation insulator.

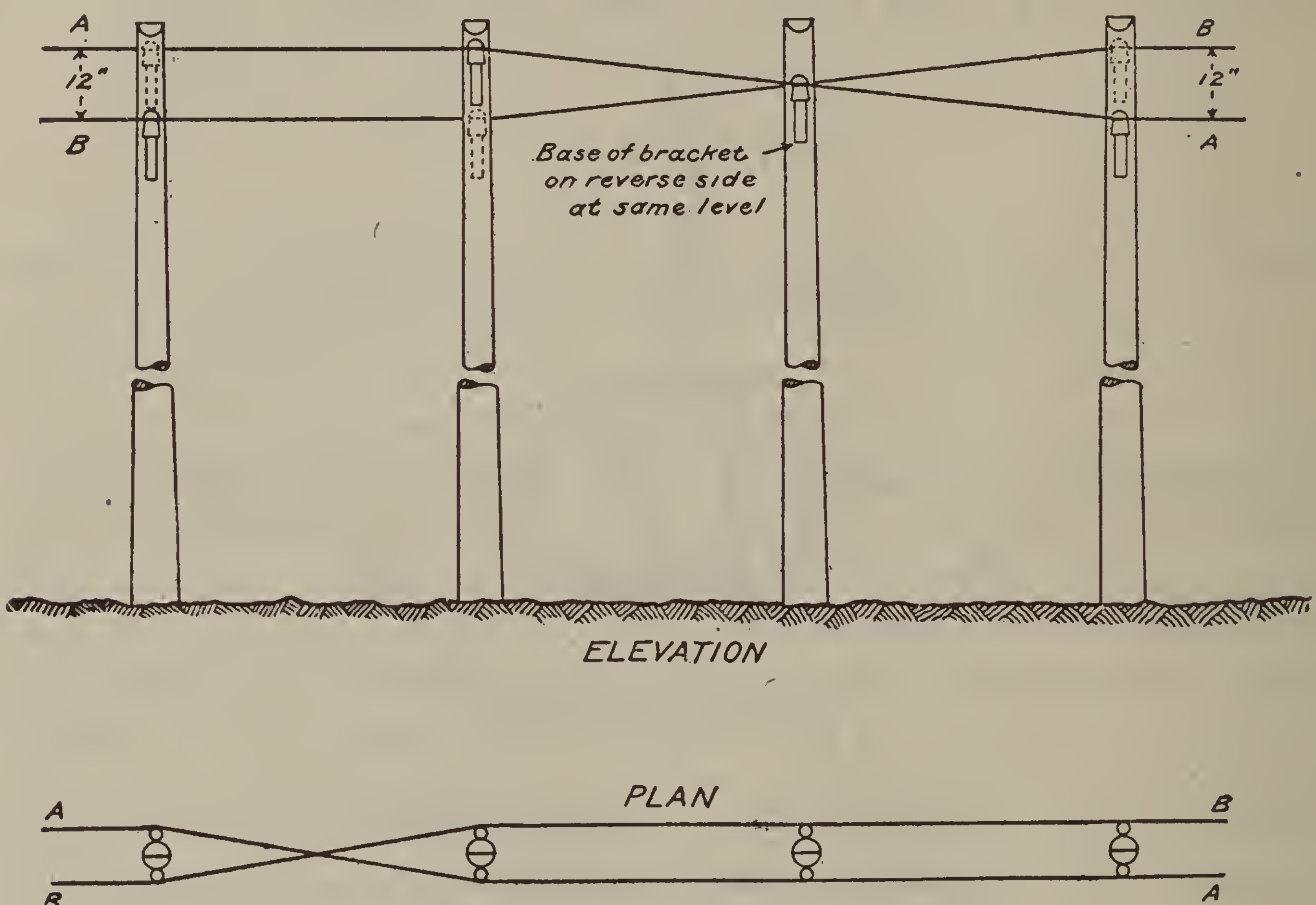

FIG. 19.—Transposition of wires (metallic circuit).

GENERAL CONSTRUCTION NOTES.

POLE STEPS.

Galvanized-iron pole steps should be used on all poles 35 feet or more in length, and at railroad crossings, and on any pole to which telephone apparatus, such as switch boxes and test stations, is attached. They should be driven into the pole on 18-inch centers at right angles to the line, so that alternate pole steps are on the opposite sides of the pole, and those on the same side are 3 feet apart. (See fig. 20.) Where used on poles or trees of exceptionally large diameter, they may be driven in at approximately right angles to each other.

CAUTIONS.

The line wire should not be handled or touched during lightning storms, either for construction or repair.

A pole should never be climbed by anyone unless he first personally tests the pole to see how strong it is. No matter how strong a pole may appear it may constitute a hazard, especially if the line wire or guy has been removed, because of butt rot below the ground line.

FOREIGN LINES.

When a Forest Service line is attached to a pole carrying a telegraph circuit, it shall be located at least 2 feet from the nearest telegraph wire. This same clearance shall be maintained from any other non-Forest Service wire on the same pole. Forest Service lines must not be attached to poles carrying electric-light, power, or high-tension transmission lines.

CROSSINGS.

CROSSING RAILROAD RIGHTS OF WAY.

Railroad rights of way should be crossed at right angles. If it will not cause too long a span, it is well to have the pole on either side of the railroad right of way far enough away from the nearest rail, so that if the pole were to fall toward the track it would not reach the rail. Under no condition should a pole be closer than 10 feet to the nearest rail. In addition, the pole on either side of a railroad track should be guyed or braced to keep the pole from falling toward the track. The lowest wire on the pole should not be less than 26 feet above the highest point of the track, and greater height must be used if required by State law or by the railroad. The wire should be tied to the pole with a figure 8 tie, and two brackets should be used for each wire on each pole of the crossing. The wire should be tied between the insulator and the pole.

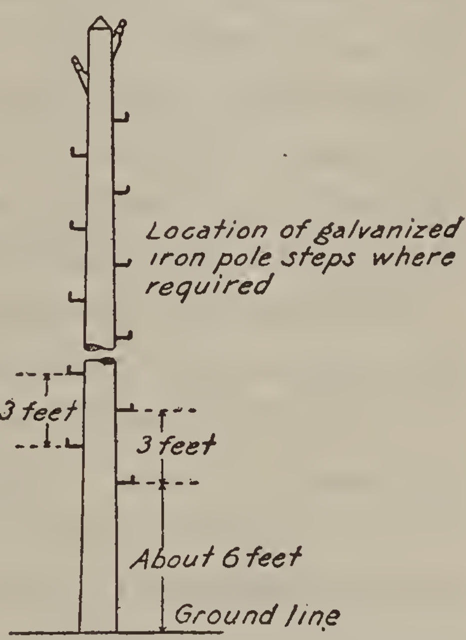

FIG. 20.—Pole steps.

CROSSING FOREIGN LINES.

Whether to cross over or under foreign lines shall be determined by the character of their construction. If the foreign lines are well constructed and well maintained they may be crossed underneath, at a distance of not less than 4 feet below the lowest wire of the foreign line, unless this would bring the telephone line too close to the ground. In that case the crossings may be made over the foreign lines, if a distance of not less than 4 feet is maintained between the lowest part of the telephone line and the highest wire of the foreign line. If the construction or maintenance of the foreign line is poor, the Forest Service line should pass overhead under all circumstances.

CROSSING ROADS.

If the line is following a road and crosses from one side to the other, the crossing poles should be braced or guyed, and a figure 8 tie used on each side of the road.

CROSSINGS OVER 500 FEET IN LENGTH.

Special construction to be taken up with the district forester should be used. This may involve the use of steel wire, special-strain insulators, towers, or bridge work, and special "A" or "H" construction.

CROSSING HIGH-TENSION TRANSMISSION LINES.

High-tension transmission lines shall, from a telephone standpoint, be treated as a hazard to life and property. This hazard shall be considered as applying to the entire telephone system if any part of the system is exposed to contact with the transmission line. Before crossing a high-tension transmission line the matter should, in all cases, first be taken up with the district forester.

Such lines must not be crossed except at a right angle. Unless the district forester specifies otherwise, or unless the transmission company has made special and safe provision for the purpose, the crossing shall be made as follows:

The line will be dead-ended on each side at a pole not closer than 150 feet away from the high-tension transmission line. The pole at each side should be properly braced or guyed. The actual crossing shall be made underground by means of an extra heavily insulated, rubber-covered, braided, and weatherproofed copper wire run underground through an inch and a half iron pipe. The joints in this pipe should be water-tight and the pipe should start at a point on the pole about 6 feet above the ground. An inverted U should be attached to the top of the pipe on each pole so that rain water can not follow the wire into the pipe. The rubber-covered wire should continue up the pole and be connected to the line wire. In crossing with a metallic circuit both wires may be run in the same pipe.

If trouble ever occurs from this source, a special form of protector, such as the No. 533 type, may be inserted at each end of the underground wire between it and the pole line. If considerable blasting would be required to put the iron pipe underground, below the frost line, it may be laid across the surface of the rock, providing it is covered with a suitable protective earth embankment to a depth of 2 or 3 feet.

If a high-tension transmission line desires to cross an existing Forest Service telephone line, the district forester should be notified and the transmission line should be so constructed as to provide safe and approved protection for the Forest Service line. In cases where the telephone is exposed to voltages in excess of 5,000 volts the following specifications shall be used as a basis for determining suitable protection:

"Specifications for overhead crossings of electric light and power lines." (See American Telephone and Telegraph Co.'s Specification No. 3414.[1])

CONNECTION OF SERVICE LINES TO OTHERS OR TO AN EXCHANGE.

Whenever it is desirable to connect a Forest Service telephone line with a line or exchange owned or controlled by others, the district forester will first be fully advised by letter as to what arrangements can be made for the connection, and this letter will include a statement of the ability to obtain night, Sunday, or holiday service, if needed in emergencies. All possible information should be given, such as the length of the Forest Service line, and, in cases where it is desired to connect directly to another line, the length of such line; the character of its construction and maintenance; the size and kinds of wire used in the construction of both lines, and whether one or both are grounded or metallic circuits; the number of instruments on both lines and the ohm capacity of the instruments on the line with which connection is to be made. The district forester will decide the best method of handling the matter and making the connections. Every precaution must be taken to make sure that trouble originating beyond the Forest Service line will not interfere with it.

CONNECTING BRANCH LINES.

In attaching a branch line to a main line, the branch line shall be dead-ended on a separate bracket and insulator, attached to the main-line pole for that purpose, so that the strain of the branch line will not come on the connection. (See fig. 21.)

When the main line is of hard-drawn copper wire, the main line should be cut in two and dead-ended on the same insulator from both directions, splicing in additional wire if necessary in order to accomplish this. The ends after dead-ending should be left long enough to be spliced together in a copper sleeve so as to complete the circuit

[1] These specifications are identical with and reprinted from section No. 4 in the report of committee on overhead line construction of the National Electric Light Association at its thirty-fourth convention, held in New York City, May 29 to June 2, 1911. Section No. 4 is entitled "Specifications for overhead crossings of electric light and power lines. Joint report of the committee on overhead line construction, National Electric Light Association; high-tension transmission committee, American Institute of Electrical Engineers; committee on power distribution, American Electric Railway Association; committee on high-tension wire crossings, Association of Railway Telegraph superintendents; subcommittee of committee on electricity, American Engineering and Maintenance of Way Association."

again. The branch line is then dead-ended on a separate bracket and insulator and the connection made. (See fig. 22.)

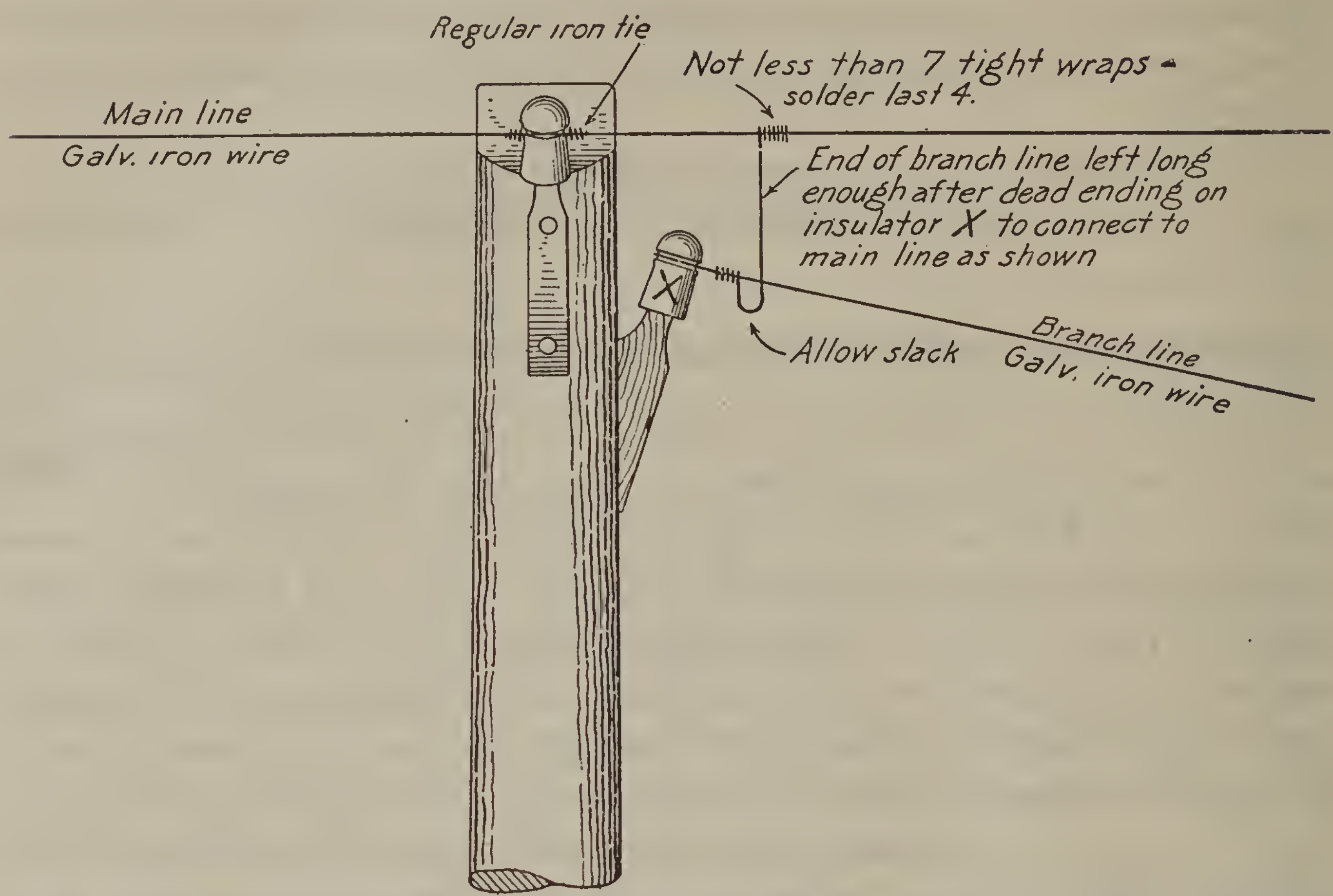

FIG. 21.—Method of connecting branch line to main line when both are of galvanized-iron wire.

Whenever any wire is connected to a hard-drawn copper line, the latter must always be dead-ended for that purpose, so that the wire

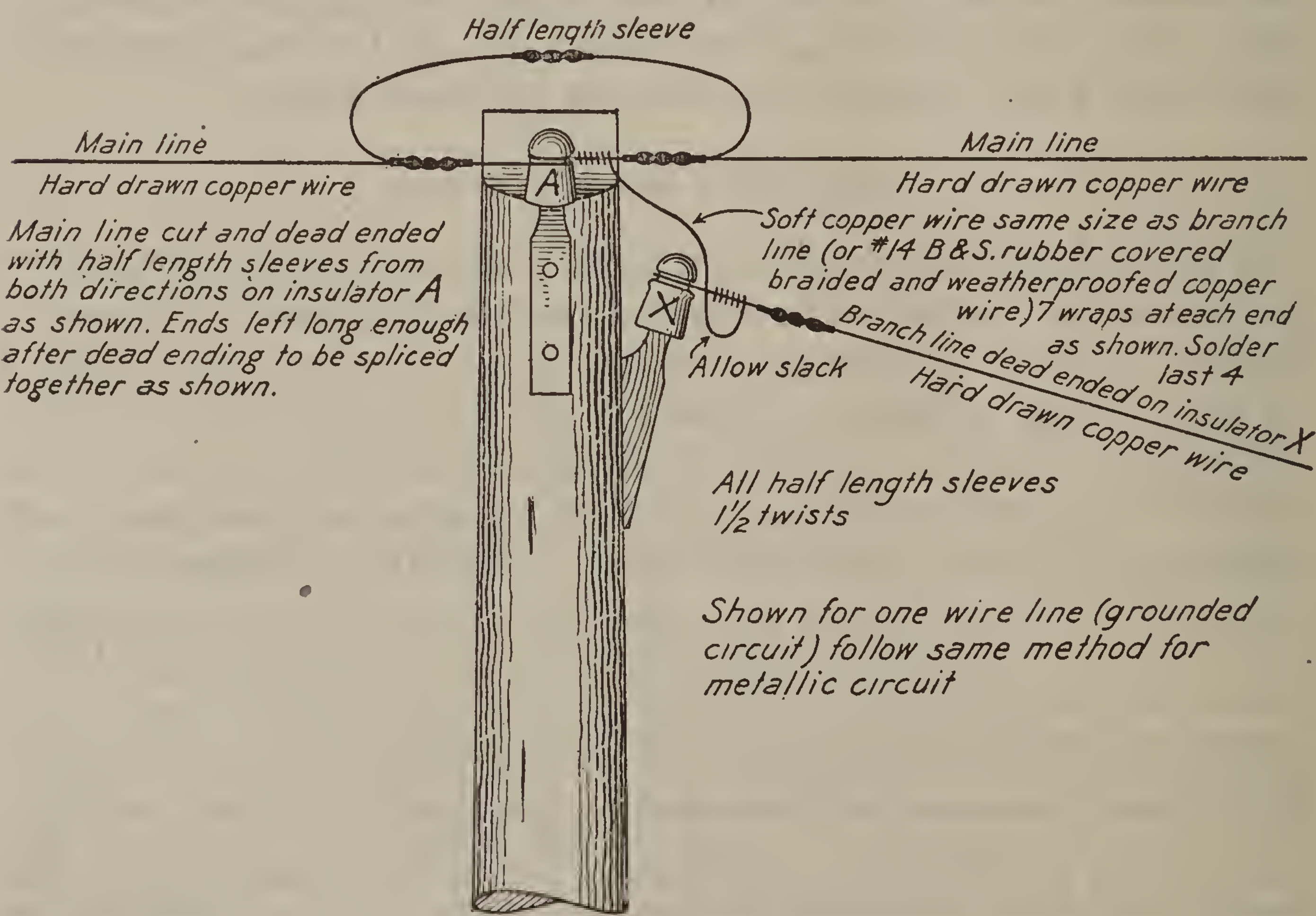

FIG. 22.—Method of connecting branch line to main line when both are of hard-drawn copper wire.

may be soldered to a point on the dead-end loop between the sleeve and the insulator. There may be times when soldering is not feasible, although desirable, and in all such cases the wires must be cleaned bright and the wire to be connected must be wrapped around the line wire not less than seven tight close wraps.

INSTRUMENTS.

Where a Forest Service line is to connect directly, or by means of switches, to another line, the ringer coils in the instruments (and

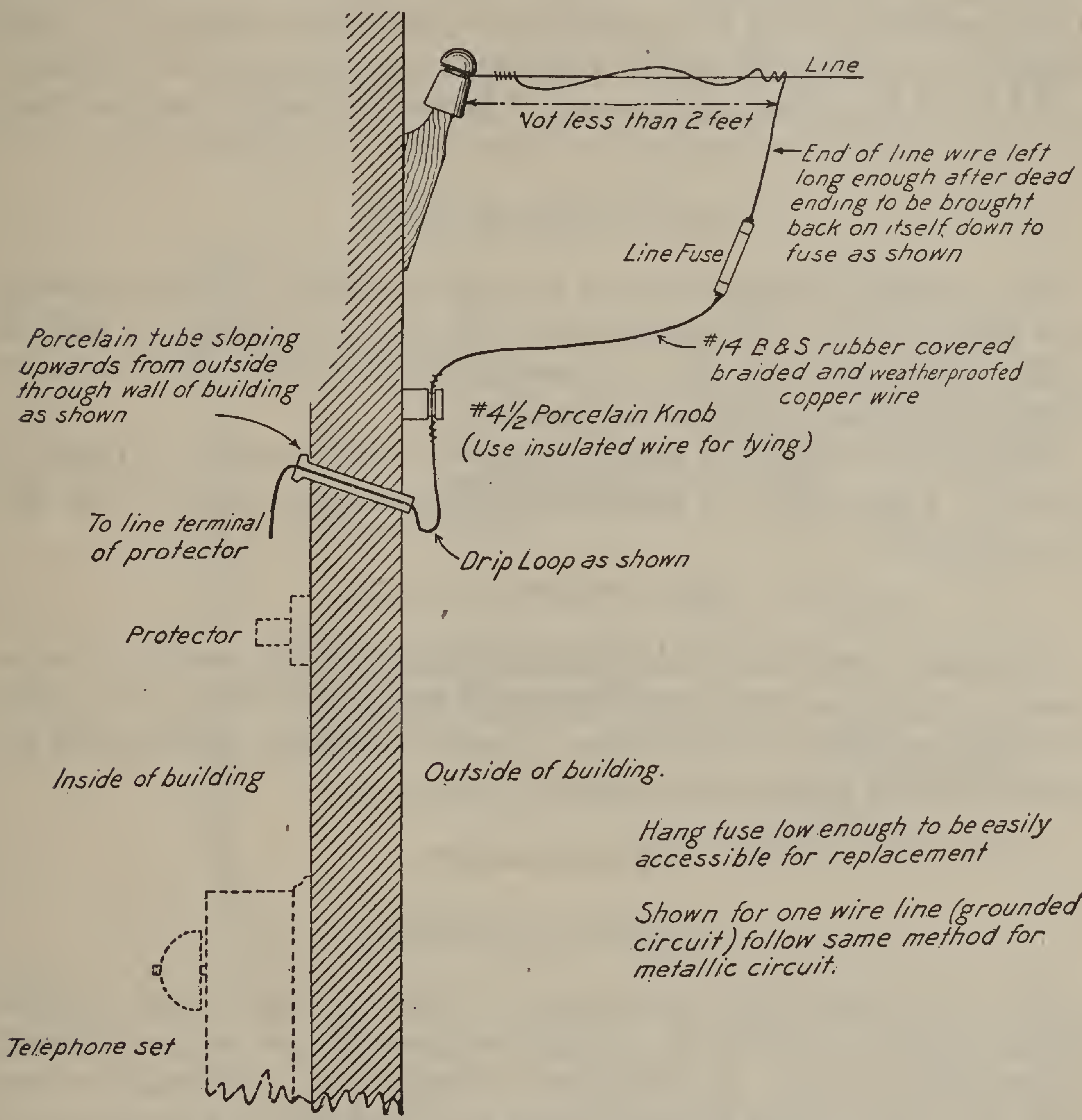

FIG. 23.—Method of installing line fuse when required.

extension bells if any are to be used) should be of the same ohm capacity as those of the connecting line. The standard capacity of all ringer coils of instruments or extension bells on exclusive Forest Service lines shall be 2,500 ohms. There may be cases, however, in connecting with other lines that are already using 1,600-ohm coils, when it will be necessary to use the same capacity coil in the instruments on the Forest Service line.

PROTECTION.

PARTIALLY EXPOSED STATIONS.

In localities where, beyond any doubt, exposure to accidental contact with electric light, power, or high-tension circuits does not exist (the only exposure of the telephone line being to lightning), each telephone station is to be considered as partially exposed and no protection at the station other than a No. 60–E protector shall be used. This protection shall be considered as standard. However, where lightning is unusually severe, additional protection in the shape of a No. 47–A line fuse may be used if located in such a position that, when blown, the wire on the side toward the line can fall away.

FULLY EXPOSED STATIONS.

In all other cases each station is to be considered as fully exposed, and both the No. 60–E protector and the No. 47–A line fuse shall be used. (See fig. 23.) The protection described for fully exposed stations shall be considered as special.

In all cases where the line is exposed to high-tension voltages, in excess of 1,800 volts, the matter shall first be taken up with the district forester.

OTHER TELEPHONE LINES.

Generally speaking, Forest Service lines need not consider the exposure along other telephone lines with which the Service lines may connect, provided the connection is made through a switchboard instead of being a permanent physical connection.

INSTALLATION.

TELEPHONE STATIONS.

It is important that instruments on both grounded and metallic lines should be installed in a proper and careful manner, in order to insure good service. In installing a telephone at a station, the wire from the line should be dead-ended on a bracket and insulator attached to the outside of the building, and located if possible on the side where the wire is to enter, so as to reduce to a minimum the outside wiring on the building.

The No. 60–E type protector should be mounted on the wall inside the building as close as possible to where the wires enter, but not out of convenient reach for inspection and cleaning, if necessary, after every lightning storm. (See Special inspection, p. 48.) The telephone instrument should be located for the best convenience of the user, with the minimum amount of inside wiring.

The line terminal of the protector should be connected to the line wire by means of No. 14 B. & S.[1] rubber-covered, braided, and weatherproofed copper wire. The ground terminal of the protector should be connected to the ground rod outside with the same kind of wire.

The line terminal and ground terminal of the protector are then connected to the proper terminals in the telephone set, which are usually marked "Line 1" and "Line 2," respectively, by means of No. 18 B. & S. rubber-covered and braided, twisted pair copper wire.

Each wire should pass through the wall of the building in separate porcelain tubes spaced 2½ inches apart and sloping upward from the

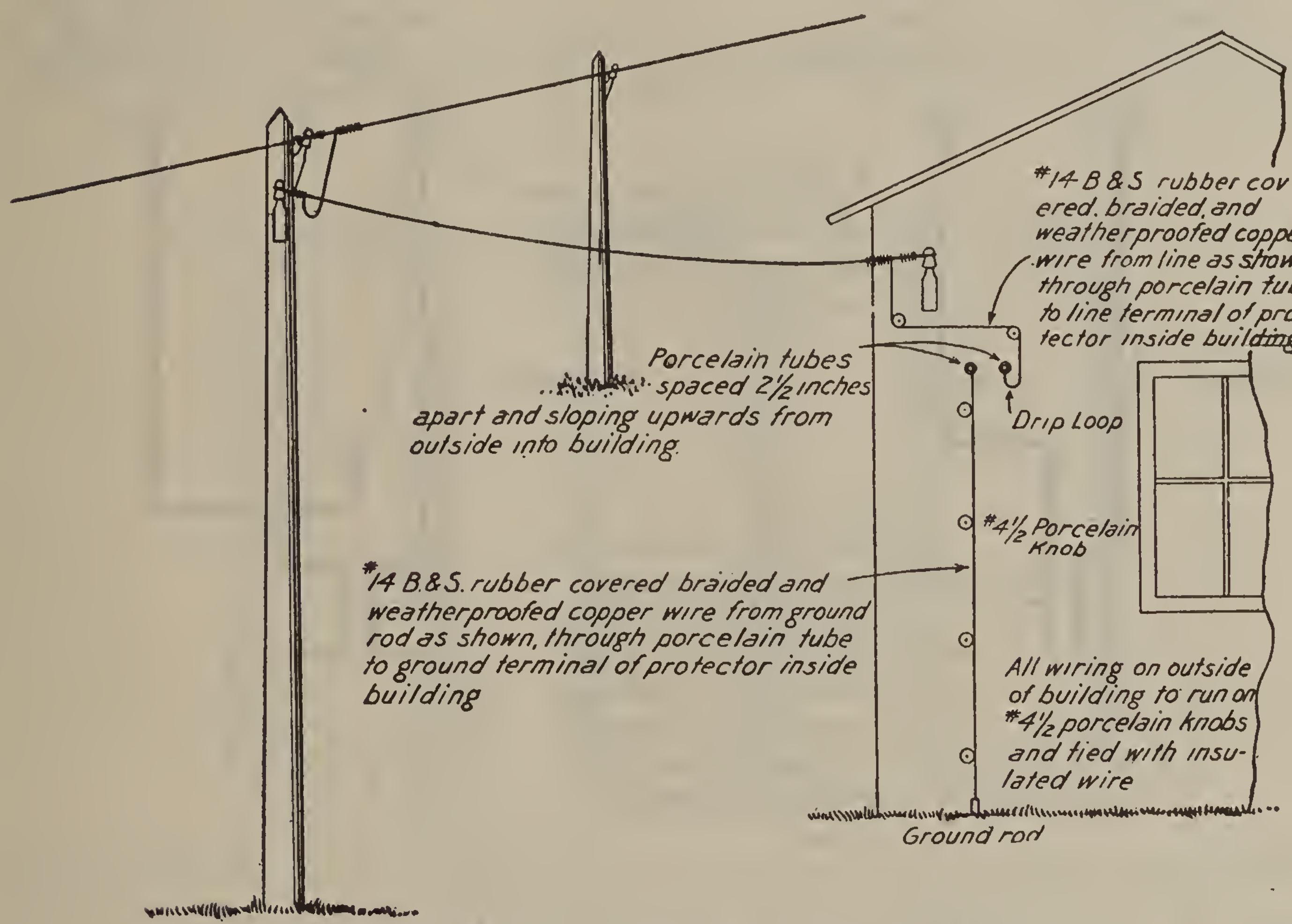

FIG. 24.—Method of installing a telephone station.

outside to the inside of the building (see figs. 23 and 24). Each wire as it enters the porcelain tube outside of the building should have a small drip loop about 2 inches long. This prevents any water that may accumulate on the wire outside from running in and causing damage from moisture.

The method of wiring and installing is shown in figures 23, 24, 25, and 26.

The method of attaching a line fuse when one is required (see Protection, p. 40) is shown in figure 23. On a two-wire line (metallic circuit) two fuses instead of one would be required if fuse protection is necessary, one being attached to each line wire.

With a two-line wire (metallic circuit) the two-line wires are run to the two-line terminals of the protector and from there on into the

[1] Brown & Sharpe (gauge).

telephone set, and a wire runs to the ground rod only from the ground terminal of the protector. In a one-wire line the wire from the line runs to only one of the line terminals of the protector (the other terminal being ignored) and continues on into the telephone set, and a wire runs from the telephone set to the ground terminal of the protector and continues on to the ground rod.

All joints and splices in wiring in the inside or outside of a house should be taped. This does not apply to the connections made at

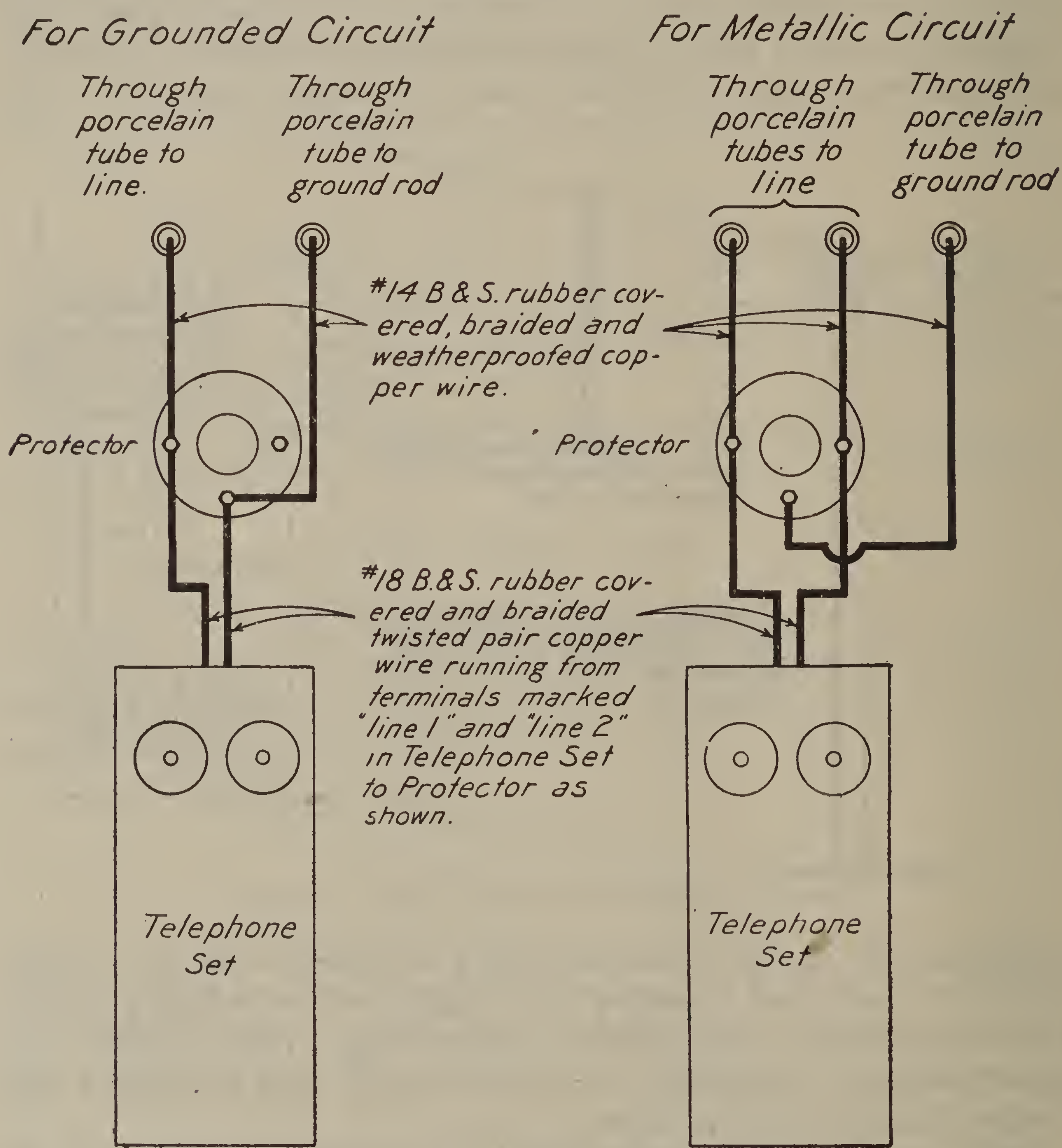

FIG. 25.—Wiring diagram for telephone station.

terminals provided in the apparatus. It is not necessary to solder the joints and splices of the wiring inside the building if they are tightly made and properly taped.

The wiring outside the building from the porcelain tubes to the line wire and ground rod should be kept away from the surface of the building by attaching it to No. $4\frac{1}{2}$ porcelain knobs (these are about $1\frac{3}{4}$ inches long), or to regular brackets and insulators if the knobs are not available. The knobs, if used, should always be attached with a 3-inch No. 16 flathead iron wood screw and not with a nail.

The telephone should be connected to the protector by means of No. 18 B. & S. rubber-covered and braided twisted pair copper wire. However, if this wire is not available the heavier insulated outside wire may be used, although it is not so cheap. The wire inside the building should be fastened to the wall with insulated tacks (such as milonite nails) or approved cleats. Staples should not be used. If the inside wiring has to pass through any walls, ceilings, or floors it should do so through porcelain tubes. No joint in insulated wire should touch an adjacent joint in another insulated wire, even though both are taped.

Wiring inside and outside of a building should be run in as nearly vertical and horizontal lines as possible. This gives an appearance

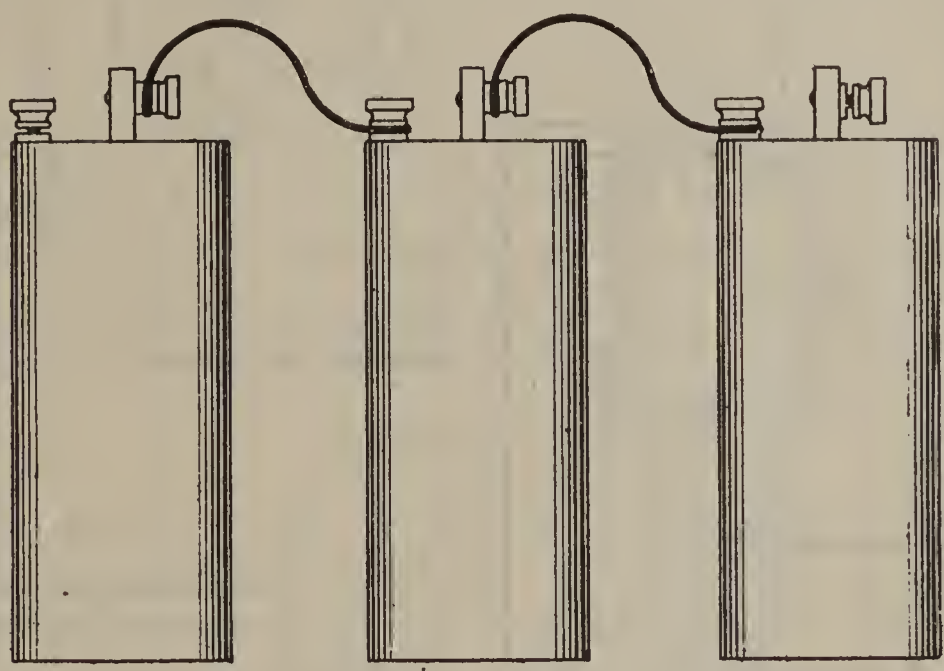

FIG. 26.—Method of connecting dry batteries for a telephone.

of neatness and simplifies tracing out the wires if hunting for trouble. Do not have any knots or spirals in the wiring (this does not mean joints and splices) between the protector and the line or ground rod. Keep the line at least 1 foot away from overhanging eaves if the roof is of sheet iron.

OUTDOOR TELEPHONE INSTALLATIONS.

Where it is desired to install an iron box telephone set outdoors it should be mounted on a post in preference to a tree or topped tree. The iron case of the box should be grounded by wrapping a wire under the head of one of the mounting bolts when the latter is screwed in and then running it to the ground rod. (See fig. 27.) A switch and protector mounting box should be attached to the post. The line wire should be properly dead-ended on a bracket and insulator located on top of the post, and should then be run down to the switch by means of No. 14 B. & S. rubber-covered, braided, and

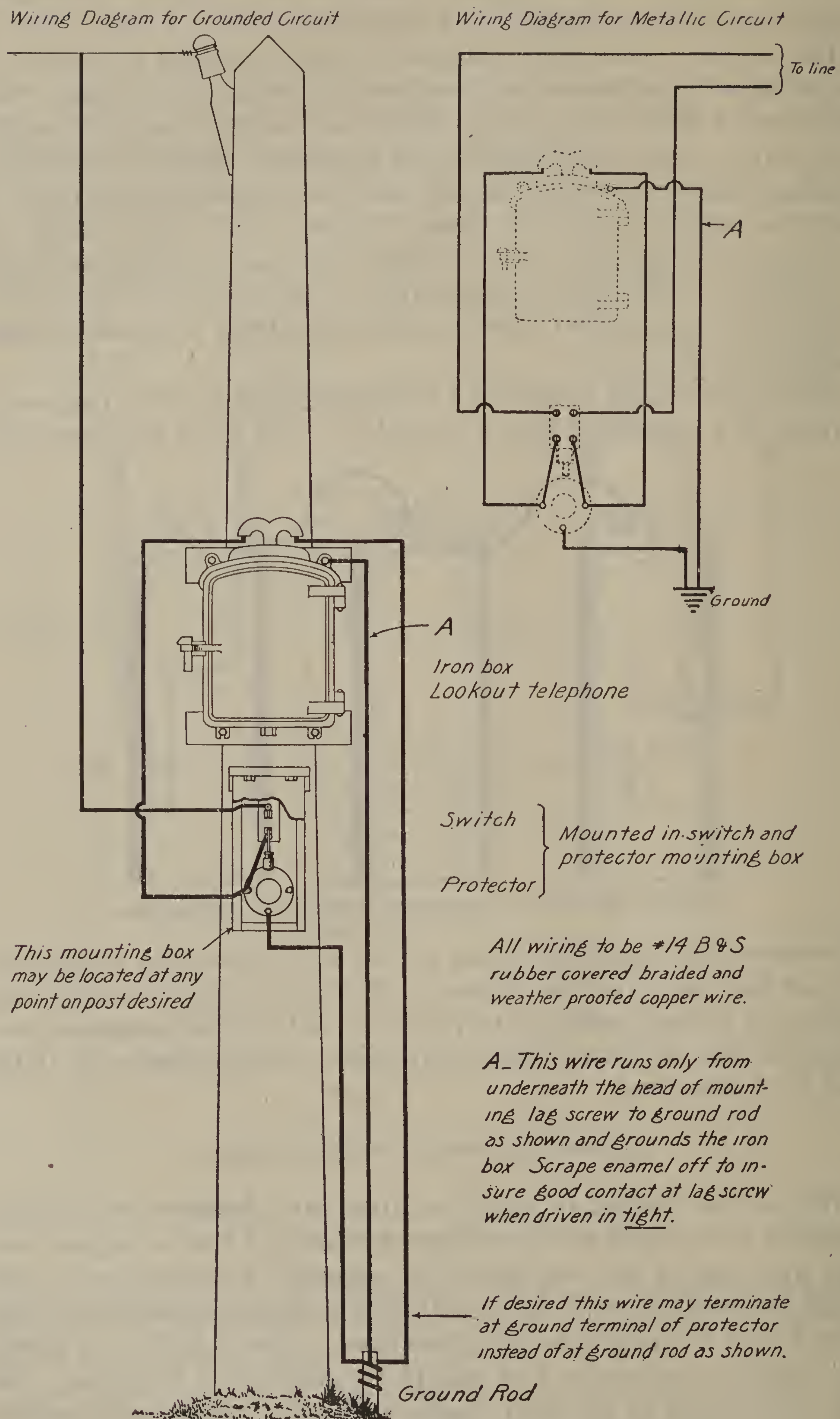

FIG. 27.—Wiring diagram for lookout telephone station.

weatherproofed copper wire. This wire should then run from the opposite side of the switch to the line terminal of the protector, and from there to the proper terminal in the telephone set through the hole in the latter provided for this purpose. The same kind of wire should run from the ground rod to the ground terminal of the protector and to the proper terminal in the iron box telephone through the hole provided in the latter for the purpose.

If this set is used on a metallic circuit, a double-pole, single-throw switch should be used in the switch and protector box (see fig. 27), and the insulated copper wire should run from each of the line wires to a switch, and from the opposite terminals of the switch, and continue on to their respective terminals on the protector, and thence into the iron box set. In this case also the iron box set is grounded from the mounting belt to the ground rod, and a wire runs from the ground terminal of the protector to the ground rod.

As installations of this character may be placed on lookout points where only rock exists, the post may be bolted to the rocks and the ground rod may be located wherever a suitable place can be found, even though it is a considerable distance away. In this case the wire to the ground rod is run in the same manner as line wire is run. Metal brackets and fixtures may be used to support the line wire along the side of the rock with extension bolts if required.

GROUND RODS.

One of the great sources of trouble on a grounded telephone line is what is known as a poor ground. When installing an instrument on a grounded circuit it is very essential that a good ground be obtained. A standard one-half inch iron ground rod 5 feet long with a copper connecting wire soldered to it should be used, and when driven to its full length into the ground where there is no rock or gravel will give the best results if the earth is damp or moist. Dry earth, gravel, and rock are not good conductors, and these are to be avoided. The ground rod may be located several hundred feet or more from the station, although this is not usually necessary. In some cases where the general character of the soil makes it very difficult to secure a good ground, a small hand coil of about 50 feet of line wire, to which is attached the ground wire leading from the station, may be thrown into a pool of water, running stream, or well. It should be inspected at least once a year to see that the wire has not rusted in two where it leaves the surface of the water.

When necessary to locate a station at a place where no moist ground can be obtained a special ground connection may be obtained by digging a pit about 2½ feet in diameter and from 6 to 10 feet deep. A small hand coil of about 50 feet of line wire should be placed at the bottom of the pit and brought up to the top. The pit should then be filled with charcoal. Charcoal is hygroscopic and will absorb and retain what little moisture there is.

MAINTENANCE.

LINE.

The entire line should be thoroughly gone over once a year and each pole inspected, preferably before the beginning of a fire season. Brackets, insulators, and tie wires which are broken should be properly replaced and all foliage and interfering timber should be cleared away. The pole inspection should look for weaknesses through butt rot (weak poles will be replaced or reenforced as required; see fig. 28 and section on Stub reenforcement) and for twist, to see that the pole has not turned to a sufficient extent to permit the line or tie wire to touch the pole. Loose guys or braces should be tightened up and all loose or badly corroded joints should be renewed.

STUB REENFORCEMENT FOR POLES.

If a pole has become seriously weakened because of butt rot near the ground line, it should be replaced except where conditions may be such as to warrant reenforcing it by means of a stub of long-lived timber, especially if suitable pole timber is not available. Such stubs may be used to reenforce poles that are sound above the ground, irrespective of their condition at the ground line. Dimensions for cedar stubs for such purposes are given in the following table:

Cedar stubs for reenforcing poles.

Length of pole.	Diameter top of stub.	Length of stub.
Feet.	*Inches.*	*Feet.*
18	7	9
22	7	9
25	8	9½
30	8½	10

The stub should start from the bottom of the pole and the diameter of the stub at the ground line should not be less than would be required for a new pole to replace the pole that is to be reenforced. The stoutest stubs should be used with the weakest poles.

The method of reenforcement is shown in figure 28. Where it is impossible to secure sufficient strength by wrapping the stub and the pole together by wire, through bolts should be used, as indicated in the illustration. The nuts, washers, and bolts should be of galvanized iron, and the washers should be about 2¼ inches square, and the bolts should be thoroughly tightened. The earth should be firmly tamped in around the stub after it has been set in place. On curves and at corners the reenforcement stub should be located on either side of the pole in line with the line wire. As far as can be judged, the pole should be located on the other side of the pole from which the greater line strain comes. In other words, the line strain should pull the pole against the stub, rather than away from it.

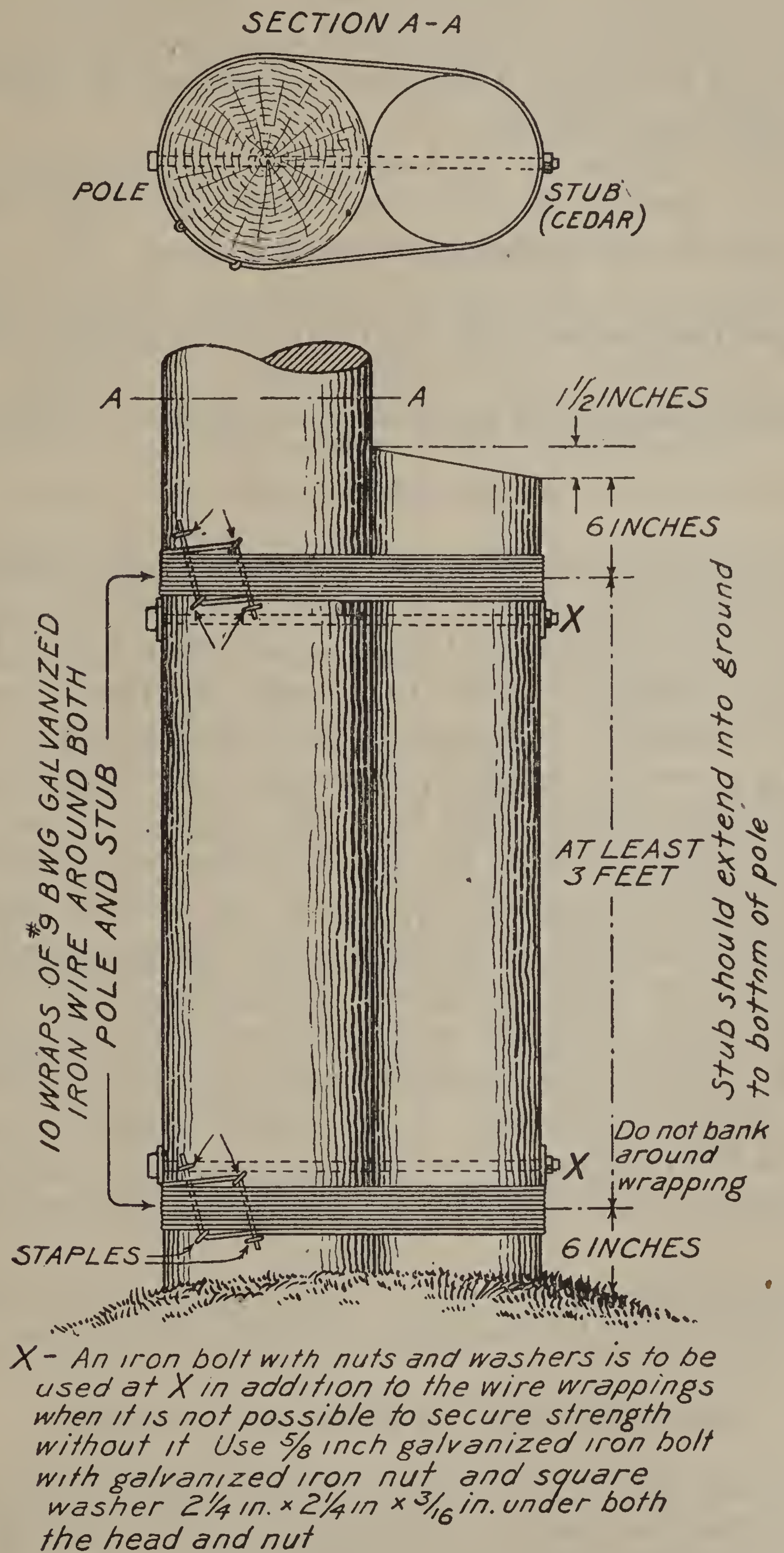

Fig. 28.—Method of pole reenforcement.

APPARATUS.

All telephone apparatus at stations and elsewhere on the line should be carefully inspected for loose connections or other defects. The inspector should call up the terminal or intermediate stations from each instrument and note particularly how the generator of the instrument rings its own bell and how the bell rings at the station called. The called station should ring back in order to test the bell at the calling station. In making tests it should not be taken for granted that something is wrong if you do not always get an answer. If unable to get the station after several attempts, call another station and try to get a test with it.

It is well to replace all dry batteries on the line at one time, in general at not greater than 12-month intervals. This should preferably be done at the beginning of the fire season. Do not connect a fresh battery to an old battery, and be sure that no battery connections have become loosened. In putting dry batteries back into a telephone, see that the zinc binding post on one battery does not touch the zinc binding post on an adjacent battery. (See fig. 26.)

SPECIAL INSPECTION.

Special inspection should be made in each ranger district by the ranger or other Forest officer in charge, immediately after severe wind, snow, sleet, or electrical storms, and after fires. All Forest officers should make it a point to examine the line wherever it is encountered during the discharge of their regular duty.

Lightning protectors should be inspected, and cleaned if necessary, after all electrical storms. The No. 60–E protector is cleaned by unscrewing the brass cap from the porcelain base, removing the metal protector blocks and cleaning them from any soot or smoke caused by lightning having jumped across the small air gap provided by the mica separator; or the lightning may have pitted the surface of these blocks so that they touch one another through the air gap just mentioned. In replacing the blocks be sure to put the mica back. In localities where the lightning is excessive and the stations are difficult of access for the purpose of cleaning these blocks, two micas may be inserted between the blocks, thus increasing the thickness of the air gap.

Especially during the fire season every ranger or guard who has a telephone should keep the lines and instruments in thorough working order.

TROUBLES AND HOW TO CLEAR THEM.

Troubles may arise from various causes: The line wire may be broken, down on the ground, or the current may be leaking, through contact with foliage, trees, poles, or other lines. The trouble may be at the stations or at pole switches; it may be caused by the switching arrangements at the terminal of the line; or it may be due to trouble on other connecting lines. Trouble is often caused by poor ground connections or bad splices and joints; in many cases the lightning protector needs cleaning; and trouble in any place is likely to affect the entire system. Inexperienced persons should not be allowed to tamper with telephone instruments, as they may cause more trouble or complicate the situation. It is usually well to have a spare telephone on each Forest which can be temporarily installed while a telephone that is in trouble is sent to the factory for inspection, repairs, or readjustment.

SPECIFIC TROUBLES.

The following are a few specific troubles with suggestion for their remedy:

(1) You can not ring up anyone; your generator handle turns hard; your bell does not ring when you turn the generator.

When testing to discover the cause of this trouble, be sure to leave your receiver on the switch hook.

First disconnect the two wires which enter the telephone set from their terminals in the set, making sure that any other wires coming to these terminals are not disturbed or left loose by this disconnection. Now turn the generator. If it turns easily and the bell rings well, the trouble is not in the telephone set.

Then connect the line wires back again to their terminals in the telephone set and disconnect the line wire from the protector, leaving the wires to the telephone set attached to the protector. Now turn the generator handle. If it turns hard, remove the metal blocks from the protector and try the generator again. If it now turns easily, clean the metal blocks by rubbing them together and then brushing them off, put the thin piece of mica between them, and put them back into the protector. Now try the generator again and if it works all right, connect the line wire back again to the protector and see if the telephone set works properly.

If the generator turns all right when the line wire is disconnected at the protector, but turns hard again when the metal blocks have been cleaned and put back and the line wire again attached, the trouble is either in the wiring between the protector and the pole or out on the line or in the wiring or apparatus at one of the other stations. Look the wiring and line over carefully for a place where one wire crosses another or a place where two wires may have been fastened contrary to instructions under a staple. If you do not find any trouble with the wiring, look for a place where the telephone line comes in contact with a tree or the ground or where one wire touches another wire.

If the generator still turns hard after the two wires which enter the telephone set have been disconnected from their terminals in the telephone set, look for incorrect wiring or crossed wires in the set or for burned-out wires in the generator.

If every station on the line has the same trouble, call for an inspection of the protector at every station on the line, or look for trouble along the pole line or in the terminal arrangements where the line is connected to a switchboard or to another line, and inquire out on that line, if necessary, or disconnect from it temporarily.

(2) You can not ring up anyone; your generator handle turns easily; your bell rings when you turn the generator.

Look for a loose connection at terminals in the telephone set, and at the protector or where the inside wiring is connected to the outside wiring. If trouble is not found at these points, look for a broken wire or poor ground connections.

(3) You can not ring up anyone; your generator handle turns easily; your bell does not ring when you turn the generator.

Look for a loose connection or a broken wire in the telephone set. It may be that one of the wires to the generator is disconnected or one of the line wires and one of the ringer wires may be loose.

(4) You can not ring other bells on the line, or only feebly; your bell rings all right when you turn the generator.

Look for a loose connection where the line connects to telephone set, where the line connects to the protector, or at the ground rod. It is possible that the trouble may be due to a poor or corroded splice in the line wire, or to contact between the line wires and trees, foliage, poles, or other lines.

(5) Your bell does not ring; other bells on the line ring all right.

Look for a broken wire or a loose connection in the wires coming from the ringer. If the connections and wire are all right, see that the ringer is properly adjusted.[1] If you can not get the bell to ring in any way, it is possible that the fine wire used for winding the coils is broken or burned out. If this is the trouble, new ringer coils will be required.

(6) You can hear others all right; others can not hear you.

Look for a loose connection or broken wire coming from the transmitter or battery. Inspect the wires connecting the batteries. See if the connections to the induction coil are all right. If this examination does not show anything wrong, thump the under side of the transmitter lightly with one hand. If this fails to improve matters the trouble may be due to an exhausted battery. When batteries are to be replaced, be sure to put in fresh coils and replace all at one time. Never connect a fresh battery to old ones.

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[1] The clapper ball of a ringer should move freely. In most cases it should have a movement of about one-sixteenth of an inch. The gongs should be so set that the clapper ball strikes but does not rest against them when thrown to either side.

(7) You hear others indistinctly or intermittently; others hear you all right.

Look for a loose connection or broken wire coming from the receiver, switch hook, or induction coil. Unscrew the earpiece from the receiver and brush out the inside and wipe off the diaphragm. If the diaphragm is bent in, turn it over and replace the earpiece.

If this does not reveal the cause of trouble, unfasten the receiver cord from the terminals in the telephone set and, while holding the receiver to the ear, touch the two terminals of the receiver cord to the terminals of one of the dry batteries. If you can hear a "click" when the cord is connected in this way the receiver is all right and there must be some fault in the wiring. If you do not hear a "click" the receiver winding or the cord probably is broken.

(8) Neither you nor others can hear distinctly.

The trouble here is probably due to some loose connection or poor or corroded joint in the wiring at the telephone station or out on the line, or to a poor ground connection, or to exhausted batteries.

(9) The stations at the terminals of the line have increasing difficulty in ringing or hearing each other plainly.

The trouble here may be due to too many stations on the line, or to too long a line for the size of wire used, or to ground rods located in too dry soils, or to corroded splices or poor joints. Any or all of these troubles may be combined with excessive line leakage through contact with trees, poles, or foliage. If fixing up the entire line improves the talking but not the ringing, see that all the telephones on the line have 2,500-ohm ringers. If this does not make the ringing satisfactory, cut off some of the stations or divide the line into sections, or rebuild the main line, using heavier wire. In extreme cases it may be necessary to build a copper metallic circuit. The fault may be due to similar conditions or poor maintenance on the foreign telephone line or switchboard to which the Forest Service line connects.

TEST STATIONS.

On lines more than 15 miles long, one or more test stations should be established along the line to facilitate the work of testing. These test stations should be so arranged that the line may be looped into the house or building where the telephone is, and the connection so made that the line wire passes through two switches placed near the telephone in order that they can be easily and quickly handled by the person making the test. The instruments should be so connected to these switches that it is possible to cut off either end of the line, and still keep the instruments on the end desired, and yet bridge to the line when both switches are closed. Thus the line may be cut by the switches for testing in either direction, and line trouble may be more readily located between certain definite points than without the aid of the test stations.

If desired, provision can be made at any point on a line for testing it in either direction with a portable telephone if the line wire is cut and dead-ended from both directions on the same pole with a two-piece transposition insulator (or two brackets), and with the ends left long enough after dead-ending to be jointed together with a test connector, so as to complete the circuit when not being tested. The arrangement is seen by referring to figure 22, and substituting a two-piece transposition insulator for the insulator marked *A* and substituting a test connector for the overhead half sleeve shown. The same scheme applies to a metallic circuit.

EMERGENCY REPAIRS.

All supervisors' headquarters and ranger stations should have on hand, in addition to the climbers, connectors, pliers, Buffalo grips, pulley blocks, rope, and other necessary tools for making repairs, about 200 to 300 feet of line wire and a small supply of brackets, insulators, and nails to be used for temporary repair work.

Supervisors' headquarters should have on hand, in addition to this material, a spare telephone and insulated outside and inside telephone wire. It is not advisable to keep more than an emergency supply of dry batteries [1] in stock, as they deteriorate whether in use or not.

Each station that has a line fuse should keep a few extra line fuses to replace those burned out. If a fuse is burned out and a new one is not immediately at hand, the wire from the station that runs to the line fuse may be temporarily connected to the outside line, but a new fuse should be secured and put in place as soon as possible.

DISCONNECTING BRANCH LINES IN WINTER.

Branch lines running to a lookout point or to a ranger station not used during the winter may be disconnected from the main line by means of a suitable pole switch properly housed,[2] as any trouble occurring on them is liable to put the entire telephone system out of commission. The pole switch in such cases would be mounted on the pole shown in figure 21 or figure 22, and connected between the branch line and the main line with No. 14 B. & S. rubber-covered, braided, and weatherproofed copper wire.

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[1] In extreme emergencies exhausted dry batteries can sometimes be temporarily revived so as to give sufficient current to get an important message over the line, if holes are driven through the zinc shell and water allowed to soak in through the holes thus made. (These holes can be made with an ordinary nail.) An emergency test to determine whether a dry battery is absolutely dead or not may be made by moistening the finger and gripping the carbon binding post and then touching the tip of the tongue to the zinc binding post. If a very slight acidulous taste is noted, which is different than when the carbon binding post is not touched, the battery is not absolutely exhausted, although it may be sufficiently so to be incapable of giving good transmission.

[2] A switch and protector mounting box may be used.

EMERGENCY WIRE.

Only extreme emergencies justify dependence on emergency wire as a means of communication. Its use should be limited to strictly temporary emergency purposes, since it is easily broken, and the insulation will leak in time, and either of these faults not only interrupt communication over it, but can also affect the main line to which it is attached. When used it should be patrolled. When laying it out it should be left very loose and tied every quarter mile, or oftener, so as to confine any breaking strain to a section between two ties. Frequent coils of slack should be left, which may be used for repairing breaks.

STANDARD TELEPHONE EQUIPMENT FOR FOREST SERVICE LINES.

STATION.

Telephone, wall set; type, Western Electric No. 1317–S, or equal; to have 2,500-ohm unbiased ringer and condenser.

Telephone, wall set; type, Western Electric No. 1317–R, or equal; to have 1,600-ohm unbiased ringer and condenser

Extension bell; type, Western Electric No. 127–F, or equal; to have 2,500-ohm unbiased ringer.

Extension bell; type, Western Electric No. 127–G, or equal; to have 1,600-ohm unbiased ringer.

Telephone, lookout; type, Western Electric No. 1336–J, or equal; to have 2,500-ohm unbiased ringer and condenser.

Telephone, lookout; type, Western Electric No. 1336–K, or equal; to have 1,600-ohm unbiased ringer and condenser.

Switch and protector mounting box only; type, Western Electric D–400, or equal.

Protector; type, Western Electric No. 60–E, or equal.

Line fuse; type, Western Electric No. 47–A, or equal, for line at stations when required.

Protector blocks; type, Western Electric No. 20, and No. 21, or equal; for repairing No. 60–E protector.

Protector block mica; type, Western Electric No. 3, or equal; for repairing No. 60–E protector.

Ground rod; type, Western Electric No. 94033 (or 52108), or equal; to have copper wire soldered to end.

Dry battery; type, Western Electric No. 100028 Blue Bell dry battery, or equal; for station telephones.

Repeating coil; type, Western Electric No. 37–A, or equal; for special cases where a grounded line is connected to a metallic circuit.

Switch, single-pole single-throw porcelain-base knife switch; type, Western Electric No. 1436, or equal.

PORTABLE.

Telephone, Forest Service portable; special design for Forest Service work.

Ground rod, Forest Service portable; special design for Forest Service work.

Line connector, Forest Service portable; special design for Forest Service work.

Dry battery, portable; for Forest Service portable telephone.

FIELD.

Brackets.—Twelve-inch painted oak brackets, conforming to specification of the American Telephone & Telegraph Co., should be used.

Wire.—Galvanized-iron wire, quality B. B., conforming to specification of the American Telephone & Telegraph Co., should be used, excepting on long spans of over 500 feet, where special instructions from the district forester should be asked for by the supervisor or man in charge of telephone work.

Insulators.—Line insulators of the type known to the trade as regular pony long-distance type, weighing approximately 14 ounces each, conforming to specification of the American Telephone & Telegraph Co., should be used.

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